LOGY DEPARTMENT

June 1947

TECHNOLOGY REVIEW

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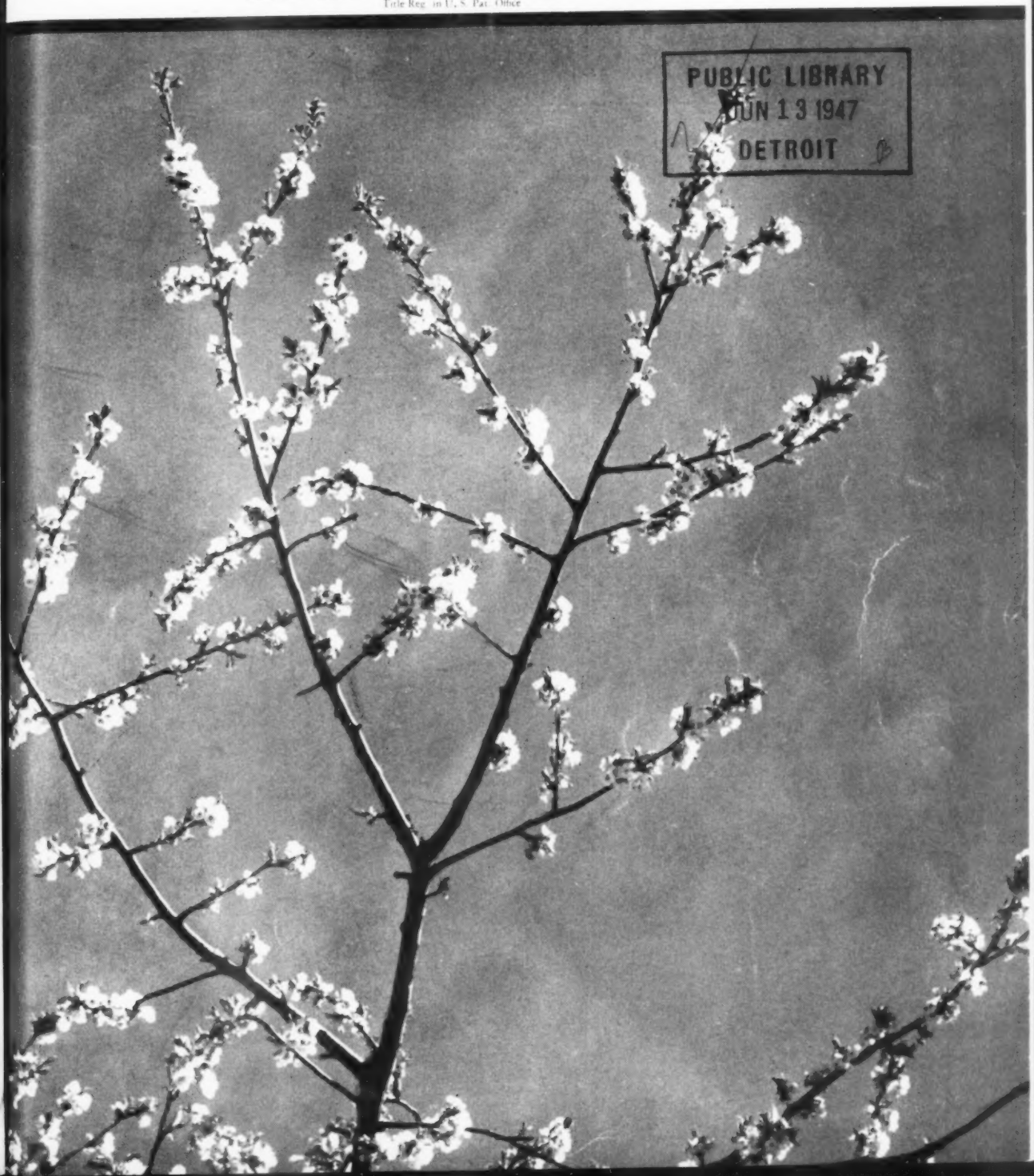

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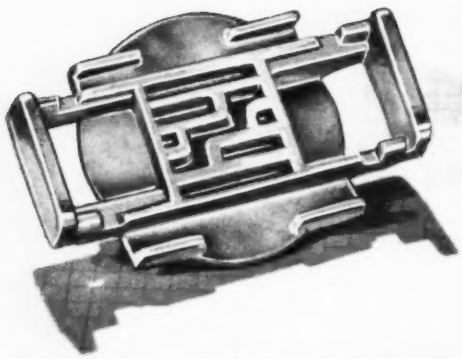
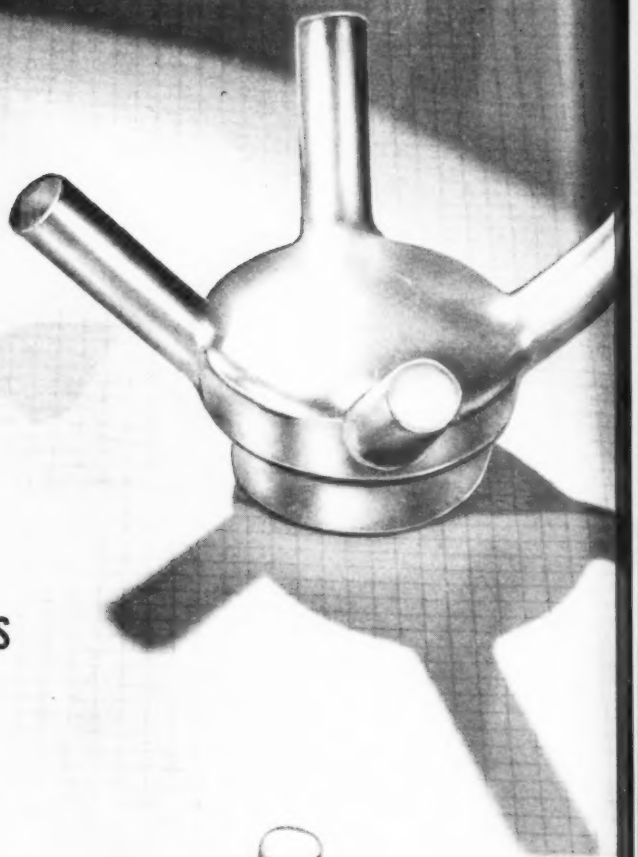
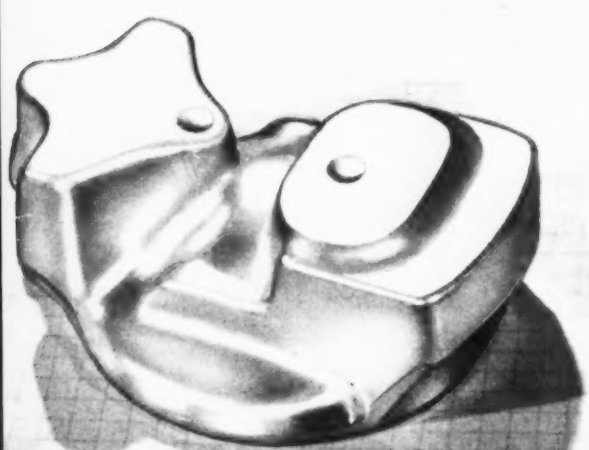
IMPROVE QUALITY.. LOWER COSTS..*USE* FORGIN





UNLIMITED APPLICATIONS



THE HARVEY METAL CORPORATION

HAROLD S. HARVEY '05 • *Engineers & Manufacturers* • SHERRY O'BRIEN '17

74th STREET and ASHLAND AVENUE • CHICAGO 36, ILLINOIS

FORGINGS IN ALUMINUM • BRASS • BRONZE • COPPER • MAGNESIUM • MONEL • ALLOYS

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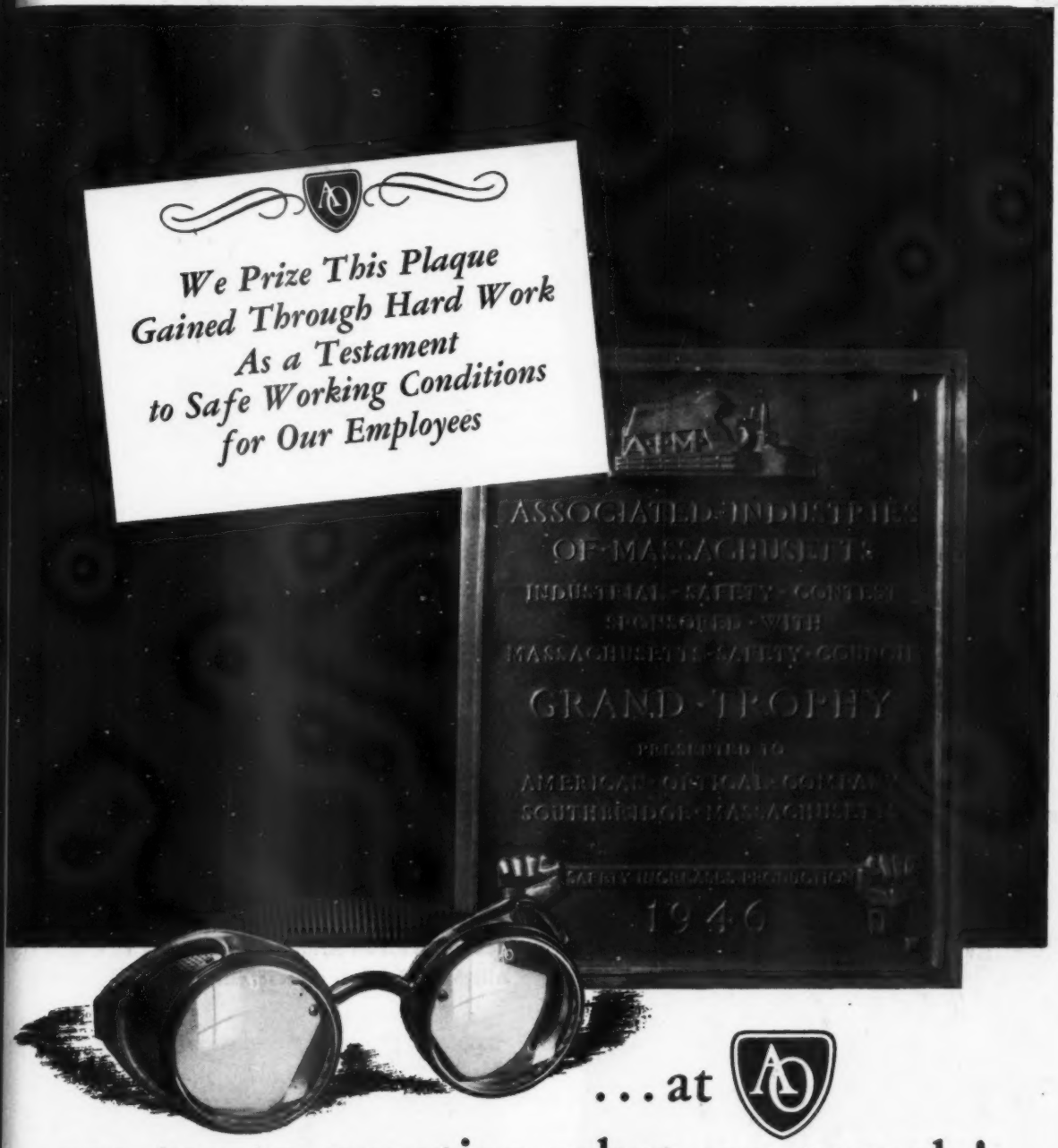

...at AO

we try to practice what we preach!

American Optical Company, in competition with 325 companies has won the state-wide accident prevention contest for 1946 and has received the Grand Trophy presented annually to that Massachusetts concern judged to be the safest in which to work. We prize this honor highly, not for the trophy merely, but because the attainment of the safest working conditions for our employees, earned through unremitting effort, is its own reward. In this spirit, we are also pleased that the award in the Commercial Vehicle Accident Reduction Contest was won by AO for operating its trucks during 1946 without accidents.

At AO we try to practice what we preach... it *pays off* in dollars and cents! Our eye-accident prevention and eye-protection program includes vision checks and examinations, corrective glasses if needed, safety-goggles for employees with defective vision, and occupational glasses for employees on jobs requiring special visual skills and attention.

Your nearest AO representative can supply complete details about a program which can improve worker output and morale, reduce accidents and spoilage and lower production costs. Ask him to call.

American Optical Company — *Safety Division*

SOUTHBRIDGE, MASSACHUSETTS • BRANCHES IN PRINCIPAL CITIES

THE TECHNOLOGY REVIEW, June, 1947. Newsstand Edition. Vol. XLIX, No. 8. Published monthly from November to July inclusive at 10 Ferry Street, Concord, N. H. Publication date: twenty-seventh of the month preceding date of issue. Annual subscription $3.50; Canadian and Foreign subscription $4.00. Entered as second-class matter at the Post Office at Concord, N. H., under the Act of March 3, 1879.

ARNOLD

Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS

Arnold's business is permanent magnets, *exclusively*—a field to which we have contributed much of the pioneering and development, and in which we have set peak standards for quality and uniformity of product.

Our service to users of permanent magnets starts at the design level and carries on to finish-ground and tested units, ready for your installation. It embraces all Alnico grades and other types of permanent magnet materials—any size or shape—and any magnetic or mechanical requirement, no matter how exacting.

Let us show you the latest developments in permanent magnets, and how Arnold products can step up efficiency and reduce costs in your magnet applications. Call for an Arnold engineer, or check with any Allegheny Ludlum representative.

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Specialists and Leaders in the Design Engineering and Manufacture of PERMANENT MAGNETS

W&D 1100

Grinding is with you from morn' till night

- Grinding had a part in producing the alarm clock that wakes you in the morning — and it plays a part in producing almost everything that you use throughout the whole day.
- Your morning newspaper is made of groundwood pulp — your breakfast cereal is produced by steel rolls ground smooth and true.
- Grinding had much to do with making the 8:15 and the rails on which it runs.
- Your office machinery and equipment are products of grinding — also your recreational paraphernalia.
- Thousands of grinding operations played a vital part in producing your automobile.
- The furniture in your home was cut and shaped with ground tools and finished with abrasives.
- That final midnight snack comes from a refrigerator whose dependability is due to precision grinding.
- And even from night to morn' grinding is with you — it had a hand in producing the oil burner that keeps your home comfortable.

And wherever grinding is done you'll find NORTON

. . . for Norton is the world's largest producer of abrasives, grinding wheels and grinding machines. At Norton you'll find the engineering skill to solve all your grinding problems. And it's available through Norton branches and distributors the world over.

NORTON COMPANY, WORCESTER 6, MASS.

Behr-Manning, Troy, N. Y., is a Norton Division

NORTON ABRASIVES

FOR INDUSTRY

Carbon Black
Natural Gas
Natural Gasoline
Pumping Equipment
Pine Tar
Charcoal

The list of finished products using Cabot raw materials is much longer than that of the materials themselves, because of their extraordinary versatility. Carbon black, for instance, has several distinctly different uses in the automotive industry. One of these is in tires, where carbon black is an indispensable reinforcing agent.

Yet another Cabot ingredient in tires is pine tar, provided by the Retort Chemical Division of Cabot Carbon Company. It is an essential in rubber as a softener. Cabot pine tar also has many other uses, notably in the cordage industry, in shipbuilding and maintenance, and in the manufacture of medicinals and pharmaceuticals.

CABOT CARBON CO.
TEXAS ELF CARBON CO.
GENERAL ATLAS CARBON CO.
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CABOT

GODFREY L. CABOT, INC.
77 FRANKLIN STREET · BOSTON 10, MASS.

To Technology Men in PETROLEUM MARKETING...

- *Do you like Spilled Gasoline?*

What your answer should be is obvious — because it is the Petroleum Marketer (and the car owner) who really pay the penalty for the unsatisfactory conditions now present in automotive gasoline tank design. Spilled gasoline is only a symptom — not the disease.

You – the Petroleum Marketer – and nearly a million men engaged in the final phase of marketing gasoline – are confronted more than a billion times a year with the problem of blindly filling automotive gasoline tanks. Many of these tanks will accept the gasoline at only about one half the speed of your pumps.

What is the result? Your employees take twice as long to fill tanks as they should. Your investment in filling stations is not nearly as productive as it should be. Due to spillage, cost of maintenance is increased. Customers hesitate to say, "Fill 'er up." Fire hazards to life and property are multiplied.

Why not ask your own attendants how they like to fill a Packard Clipper, Chrysler Imperial or Willys Station Wagon — all equipped with the VENTALARM whistling tank fill signal. I'll wager you will discover that these cars have the attendants' good will — and cost less money to fill.

It is my belief that the automotive manufacturers do not realize the hardships that are being visited upon you by inefficient gasoline tank design. In your own self-interest, why not inform the manufacturers how slow-filling, always-spilling gasoline tanks adversely affect your operations — and you might mention VENTALARM.

If new cars were to be VENTALARM-*equipped —*

What would be the manufacturer's cost per vehicle?	**Pennies**
What would the consumers save?	**Millions**
What would Petroleum Marketers save?	**Millions**

Yours, for fast-filling, non-spilling gasoline tanks,

Frank P Scully

M.I.T. '15

P.S. Any Tech man who would like VENTALARM for his own gasoline tank, or who desires to examine its simplicity of construction, is welcome to one with my compliments. (There is an installation expense in equipping old tanks.)

*T. M. REG. U. S. PAT. OFF.

Over a million homes are now equipped with the VENTALARM fuel oil tank fill signal. The driver never enters the home.

SCULLY SIGNAL COMPANY • **98 FIRST STREET, CAMBRIDGE 41, MASS.**

ETHYLENE

recoveries over 90%
purities over 95 mol %

100,000 pounds of ethylene per day are produced by this plant, designed and built by The Lummus Company.

. . . without low-temperature refrigeration

In 1943 Lummus completed construction of an ethylene plant for one of the nation's best known chemical companies. With this plant (the first to employ the absorption process for the purification of ethylene) the company has consistently obtained high ethylene recoveries (over 90%) and purities (up to 95 mol %) without use of extreme low-temperature refrigeration.

Among other basic advantages which Lummus incorporated in this plant are flexibility, economical resolution of the charge and furnace effluent gas streams, and ease of control.

Lummus is currently completing construction of two similar ethylene plants with even higher purity—99+mol % ethylene.

With complete research and construction facilities—and with broad experience in petroleum refining and chemical production—Lummus is well prepared to design and build your facilities for the production of ethylene, propylene, phenol, and other chemicals from petroleum.

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chemical processes and plants

CHICAGO—600 South Michigan Avenue, Chicago 5, Ill.
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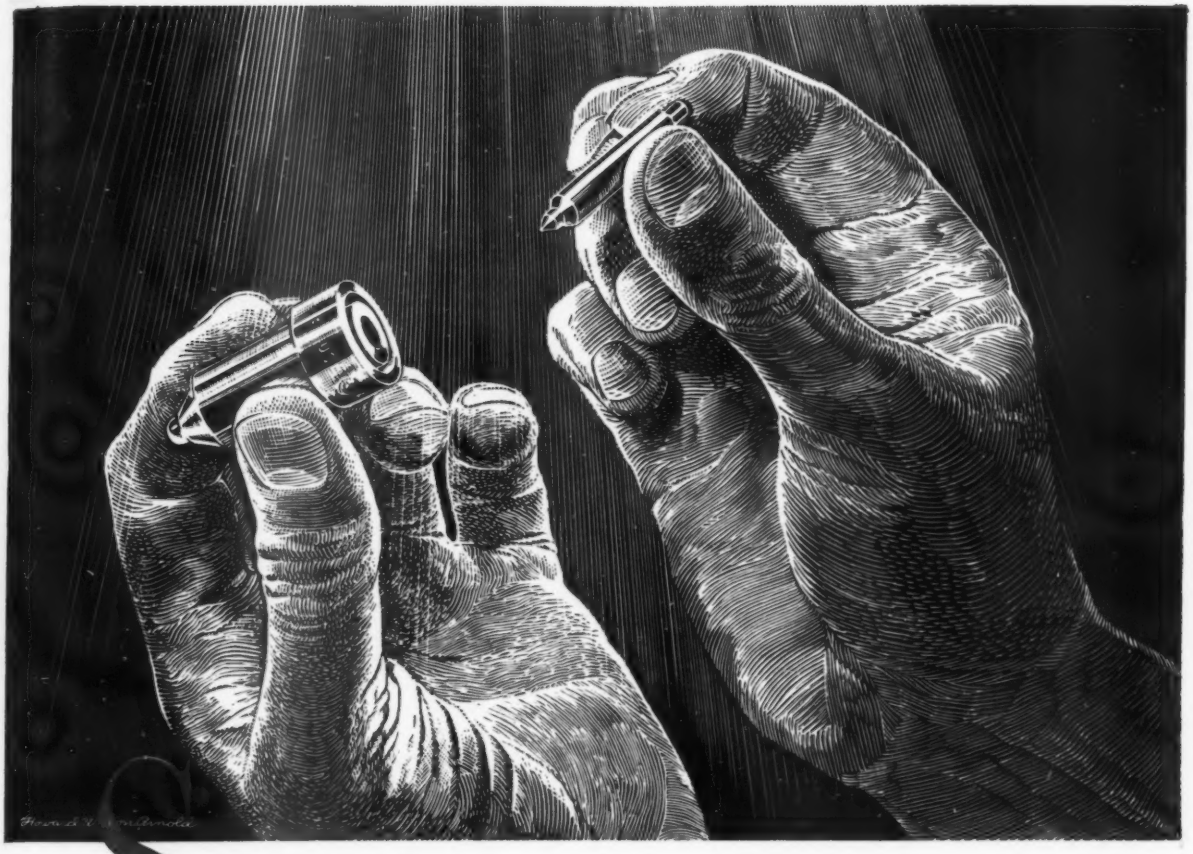


SKILL ..at your Service

At American Bosch, the experience-born skill of thousands of pairs of hands operating modern machines is at the service of the American Diesel industry and its thousands of users.

So, too, are available the experience of engineers who have worked closely with the industry for years . . . fully equipped laboratories . . . productive capacity that has kept pace with the industry's rapid growth . . . field service which keeps the equipment operating as the makers intended . . .

. . . which may serve to explain why a large majority of America's Diesel Builders equip their engines with American Bosch Diesel Fuel Injection Equipment. AMERICAN BOSCH CORPORATION, Springfield 7, Mass.

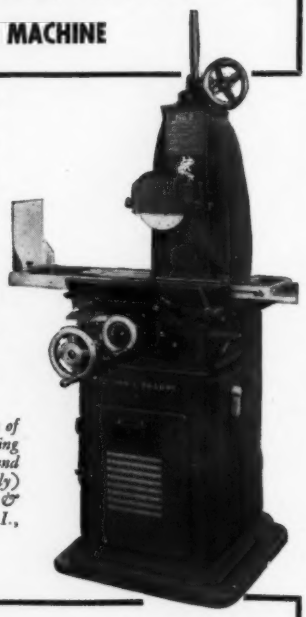
Diesel Fuel Injection

AMERICAN BOSCH

AUTOMOTIVE AND AVIATION ELECTRICAL PRODUCTS

NEW DESIGN No. 2

SURFACE GRINDING MACHINE



Alternative drives . . . motor in base or motorized spindle.
Two rates of table feed . . . 19 or 31 ft. per minute.
Choice of plain bearing or antifriction bearing spindle unit . . . interchangeable cartridge type.
Improved column construction . . . for increased rigidity.
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● *Ask for specifications and details of numerous attachments for broadening the range of usefulness of the No. 2 and the No. 2B (with hand feeds only) Surface Grinding Machines. Brown & Sharpe Mfg. Co., Providence 1, R. I., U. S. A.*

B·S

BROWN & SHARPE

HEVI DUTY

Hevi Duty Electric Co.

Surges Transformers

With the acquisition of the Surges Electric Company of Milwaukee, Hevi Duty can now offer quality dry type air cooled transformers with or without tap changing switches as well as special transformers for special requirements. An accelerated program of modernization will present opportunities for increased production and good delivery schedules.

Write for Bulletin S-4611

HAROLD E. KOCH '22, *President*

ELTON E. STAPLES '26, *District Manager, Cleveland*

HEVI DUTY ELECTRIC COMPANY

HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY

MILWAUKEE 1, WISCONSIN

THE TABULAR VIEW

Salubrity. — The rigors of pursuing strenuous courses of high academic standing at the Institute presuppose sound health on the part of M.I.T. students and staff. Every effort is made to assure that those entering the Institute are in sound health, and that that state of well-being is perpetuated. At the same time, as DR. DANA L. FARNSWORTH points out in "Maintaining Student Health at M.I.T." (page 459), general medical service (complete with dental, eye, and psychiatric clinics, x-ray and pathological laboratories, and an operating room) is immediately available when emergency or corrective measures are required. Dr. Farnsworth, Director of the Medical Department since the fall of 1946 when he succeeded Dr. George W. Morse, is assisted by a staff of physicians, nurses, and clerical workers who are required to take care of the 33,000 calls which are made annually, on the average, to the Homberg Infirmary. A biography of Dr. Farnsworth appeared in the June, 1946, issue of The Review.

Security. — If the nation's economic and political security (or the world's for that matter) depends on anything, it relies on science and the future generation. In this issue, VANNEVAR BUSH, '16, President of the Carnegie Institution of Washington, addresses himself (page 463) primarily to young people on the matter of science. "The Scientific Way," made available to The Review by former editor Frederick G. Fassett, Jr., is the major portion of Dr. Bush's recent address to winners of the Westinghouse science contest, and reflects the author's salty philosophy. But for all his eminent attainments, which have cast him in the forefront of American science, Dr. Bush is remembered in Cambridge primarily in terms of his earlier accomplishments. He is remembered not so much as the moving force behind "Science — the Boundless Frontier," for example, as he is known as coauthor (with William H. Timbie) of *Principles of Electrical Engineering*, as professor in the Department of Electrical Engineering, as originator and prime mover in the development of the differential analyzer, as dean of engineering, and as vice-president of M.I.T.

Sobriety. — Some sober thoughts on the relationship between engineering training and nonquantitative studies (commonly referred to as cultural or humanities subjects) are offered (page 465) by ROBERT G. CALDWELL, Dean of the Institute's Division of Humanities. In assaying "Engineering and Education," Dean Caldwell draws upon wide experience as student and teacher in history, English literature, economics, philosophy, psychology, and politics at half a dozen educational institutions including Forman College, Punjab University at Lahore. On the basis of his long career in humanistic and social studies and his broad knowledge of human problems gained during travel in various countries, Dr. Caldwell was well prepared to assume duties as minister of the United States to Portugal in 1933, and to Bolivia in 1937. He became dean of humanities in 1939.

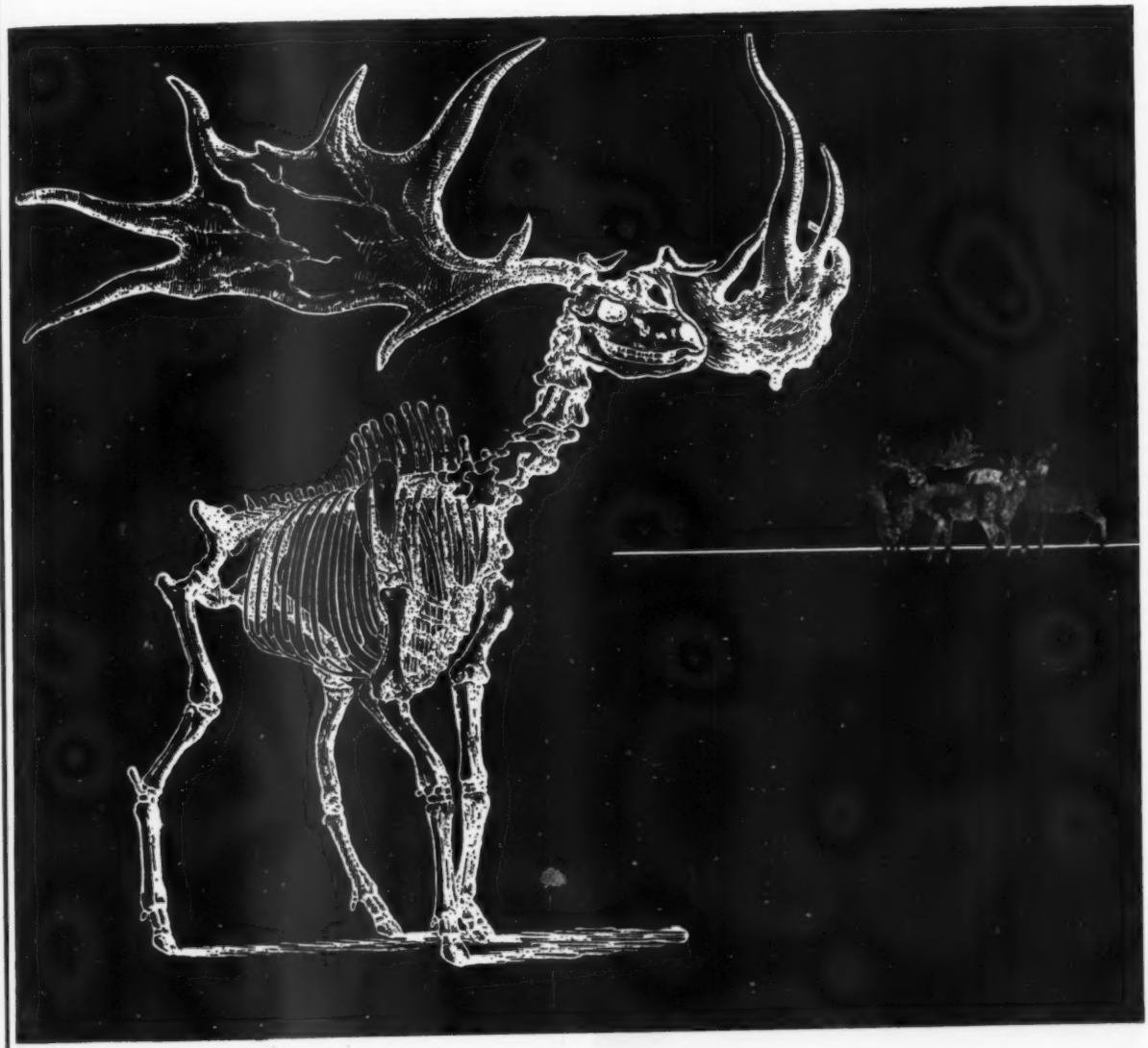
Solemnity. — That the aggregate of man's vast engineering and agricultural activities are now on such a scale as to compete with nature in changing the face of Mother Earth is cause for solemn anxiety. In support of this contention, PAUL COHEN, '35, has assembled a convincing array of interesting statistics which he presents in "Man as a Geological Force" (page 469). Since his graduation from the Institute, Mr. Cohen has been a research engineer in mechanical engineering by vocation and a skillful writer and interpreter of science and engineering by avocation. Since 1938 he has been an editorial associate of The Review, almost each issue of which contains some unusual grist from his well-used typewriter.

THE ELK THAT ALSO RAN

Once upon a time an enormous elk with out-size antlers roamed the Irish forests. He was impressive but impractical; concentration of weight in the wrong place ruined his ability to meet competition.

The same thing can happen in modern machinery. Too much weight, especially in parts subject to rapid operation, can reduce efficiency considerably. The machine may not become extinct, but it won't make many friends.

There is a simple, economical way of avoiding such troubles—specifying molybdenum steels. Their hardenability permits weight reduction with no sacrifice in ability to meet service requirements. Practical data on request.



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CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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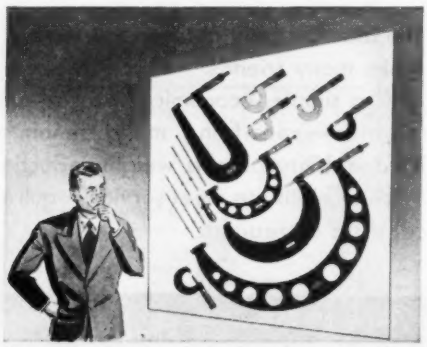
MOLY

Now that you can be "choosey" again



STARRETT MICROMETERS FOR EVERY MEASURING OPERATION

Micrometer calipers play a key part at every stage of production from tooling up to final inspection. The wide range of types and sizes again available in the Starrett line makes it easy to pick the right micrometer for any measuring or inspecting operation. And when you requisition *Starretts*, you know you're getting precision tools that have long been standard for accuracy, utility and durability in service.

Buy through your distributor

For a complete description of Starrett Micrometers and over 3000 other fine precision tools, write for Starrett Catalog No. 26 "L"

THE L. S. STARRETT CO. • ATHOL • MASS. • U. S. A.
Greatest Toolmakers

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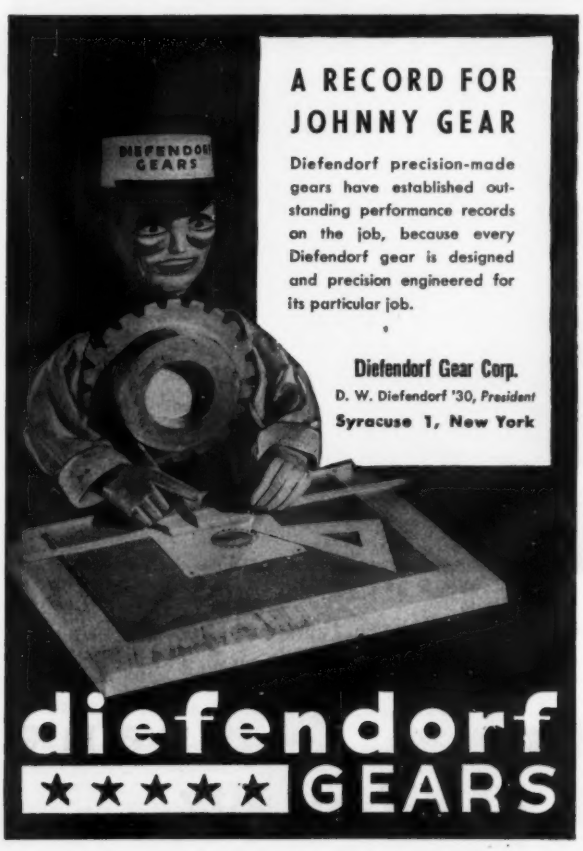
PRECISION TOOLS • DIAL INDICATORS • STEEL TAPES • GROUND FLAT STOCK
HACKSAWS • BAND SAWS FOR CUTTING METAL, WOOD, PLASTICS



A RECORD FOR JOHNNY GEAR

Diefendorf precision-made gears have established outstanding performance records on the job, because every Diefendorf gear is designed and precision engineered for its particular job.

Diefendorf Gear Corp.
D. W. Diefendorf '30, *President*
Syracuse 1, New York

diefendorf
★★★★★ GEARS

MAIL RETURNS

Solid Diet Recommended

FROM HARRY A. F. CAMPBELL, '99:

In The Review of March, 1947, "Liquid Diet for the Iron Horse" makes pleasant reading. As of today, however, there is a very limited amount of "liquid diet," taking the world as a whole.

I believe that we would be a wise country if we took a long-range view and planned to use steam locomotives and all the coal they would need. We have coal in unlimited quantities in our own mines, while at the rate we are now using oil, it will be run out in 100 years. And as a mechanical and thermodynamic machine, the following facts are still true about our latest steam locomotives:

1. For the power it develops, the steam locomotive is the cheapest machine to build and its maintenance cost per mile run is continuously being reduced.

2. The simplicity of the mechanism of the steam locomotive is still unrivaled. A Diesel locomotive will stall if overloaded. An electric locomotive will burn out. A steam locomotive will slip its wheels but will, and does, start with very big overloads.

3. Careful tests have shown that the latest steam locomotives have produced one-cylinder horsepower on 13 pounds of steam when working at 250 pounds steam pressure, noncondensing, with eight pounds cylinder back pressure. Cylinder thermal efficiency is 17 per cent.

4. As to speed, the world's record over a measured mile for a steam locomotive is 126½ miles per hour made by a Pacific locomotive on the London and North Eastern Railroad of England. The Pennsylvania Railroad's latest duplex steam locomotive Class T.T.I. hauling 1,000 tons of passenger cars on the Fort Wayne division has run 72 consecutive miles at 102 miles per hour.

5. The serviceable life of a steam locomotive on first-class schedules is 20 years, and another 15 years on secondary schedules.

As a self-contained power plant, it has no rival — 100 feet long, 15 feet high by 12 feet wide and producing 7,000 cylinder horsepower. It is simple in construction, rigid, and of moderate capital outlay. Using a fuel of which the reserve supply is enormous, the steam locomotive may yet have a very extended life.

Brockton, Mass.

No Concession for Artistic License?

FROM NEWTON S. FOSTER, '28:

My young sons (one 15 years old, and the other 11) want me to comment on the cover picture of the May, 1947, issue of The Review. Whereas the caption describes the picture as "Escapement," they think it should be "Ratchet and Pawl."

I wonder how many other Course II fellows are picking this bone with you!

Rutherford, N. J.

Speed with Economy

We have recently completed our 6th contract for
ALLIED PRODUCTS, INC.

whom we have had the pleasure of serving since 1925

W. J. BARNEY CORPORATION
101 PARK AVENUE, NEW YORK
INDUSTRIAL CONSTRUCTION
Alfred T. Glassett '20, Vice President

research

worth 100,000 dollars

. . . yours for

the asking!

Part of Westinghouse research laboratories at East Pittsburgh, Pa.

Modern pumping system for evaporating substances under test in research on Selenium Rectifiers.

Westinghouse Selenium Rectifiers are not an overnight development. Before the present process was adopted, more than 9 years of continuous research—at a cost of more than 100,000 dollars—was spent in testing of foreign and domestic types and processing experiments.

The result has been a Selenium Rectifier comparable in quality to Rectox Rectifiers . . . long recognized as having a longer life and greater dependability than any other type of metallic rectifier.

For instance: In a comparative test with other Selenium units under identical conditions—and at full rating—Westinghouse Selenium Rectifiers showed an increase in forward resistance of less than one-half that of the best units tested, indicating a longer life than any Selenium Rectifier now available.

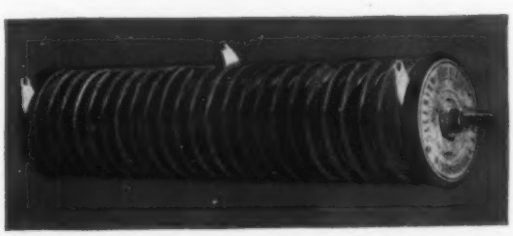
No other Selenium Rectifier unit is backed by such an intensive research program, justifying our claim that Westinghouse Selenium Rectifiers are unexcelled where long life and dependability are prime factors.

These new Westinghouse Selenium Rectifiers are ready for the market now. If you're a user of Selenium Rectifiers you can take advantage of this investment in research by outlining your requirements to a Westinghouse representative. Or write your nearest Westinghouse office for all the facts. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Penna. J-21382

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Selenium Rectifiers



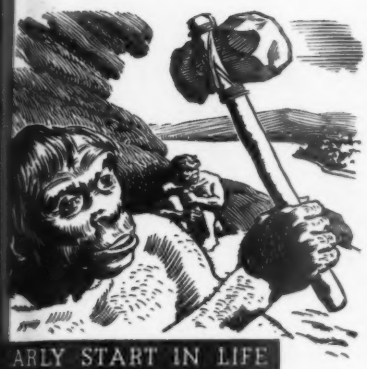
In today's fight against high costs . . . written communications move faster, easier, at less expense . . . *thanks to office systems made more efficient by the modern miracle of electronics.* The Edison Electronic Voicewriter . . . identified by its *Ear-Tuned Jewel-Action* . . . corrects the rise and fall of the dictating voice . . . sees to it that the *exact* words spoken arrive on paper at lowest cost.

Thomas A Edison

Thomas A. Edison, Incorporated, West Orange, New Jersey. (In Canada: Thomas A. Edison of Canada Ltd., Toronto 1, Ontario.)

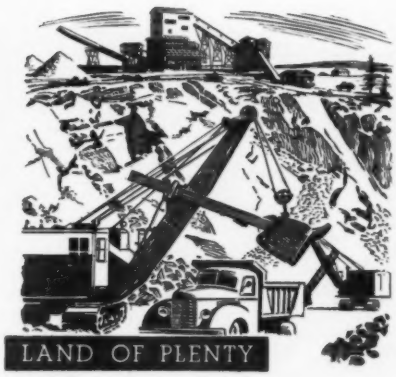
1847 · THOMAS A. EDISON CENTENNIAL · 1947

THE STORY OF SILICON



ARLY START IN LIFE

Way back in the Stone Age are found the first uses of silicon—in the tools and weapons used by prehistoric man. These were made of flint, which is almost pure silica, and in silica many centuries later the Swedish chemist Berzelius discovered the element silicon. He produced the world's first ferrosilicon in 1810.



LAND OF PLENTY

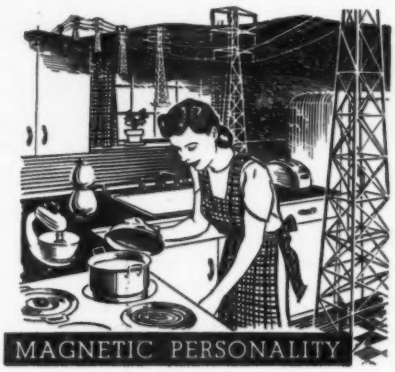
"Earth former" is what silicon has been called, for it is present in most all rocks, clays, soils, and even many semi-precious stones. More than one fourth the earth's crust is silicon — the most abundant element, next to oxygen. Electromet digs into mountain after mountain for high-quality silicon ore.

HOUSECLEANING SPECIALIST

Silicon does a "clean-up job" in iron and steel production, serving as both scavenger and deoxidizer. From the molten bath it removes harmful oxides and gases. Silicon is used for refining practically all alloy steels and many grades of carbon steel. It is second only to manganese in its usefulness in steelmaking.

A LITTLE AND A LOT

From about 0.20 to 1.50 per cent silicon goes into many structural steels—such as those used for highly stressed parts of bridges. In larger percentage, sometimes as much as 17 per cent, silicon equips cast irons to handle highly corrosive acids in chemical plants. Silicon also serves as a softener in cast iron.



MAGNETIC PERSONALITY

The heart of the mysterious transformer is made of steel containing silicon. Silicon is essential in sheet steel for electromagnets, generators, and other electrical apparatus because of the special magnetic and electrical properties it imparts to the steel. It has brought about tremendous power savings.

Cream Of The Crop

Electromet's interest in silicon dates back almost 50 years, for in 1898 the broad patent claims of de Chalmot were assigned to the Willson Aluminum Company, one of the predecessors of Electro Metallurgical Company. With its long experience in ferro-alloys production, Electromet naturally knows how to give all its customers alloys of high quality and purity. Write for the booklet "Electromet Products and Service," which will tell you more about silicon and the other Electromet alloys.

ELECTRO METALLURGICAL COMPANY
Unit of Union Carbide and Carbon Corporation
30 East 42nd Street UCC New York 17, N. Y.

ELECTROMET Ferro-Alloys and Metals are sold by Electro Metallurgical Sales Corporation, and Electro Metallurgical Company of Canada, Limited, Welland, Ontario.

Electromet
TRADE-MARK
Ferro-Alloys & Metals

You don't stay first *unless* you're best

Unseen, but contributing mightily to the long life a Goodyear tire gives you, is a *pre-tested* network of cords that make up its body.

Why is pre-testing important? You may not know it, but tire cord can be as variable as the weather.

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VOLUME 49 NUMBER 8

THE TECHNOLOGY REVIEW

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AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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From a photograph by Josef Scaylea from A. Devaney, Inc.

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Relating to the Massachusetts Institute of Technology

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THE
TECHNOLOGY
REVIEW

Vol. 49, No. 8 June, 1947

The Trend of Affairs

Out of the Past

AUTHORITY for a reminiscent item calling attention to some of the pioneer work in roentgenology in the United States is the March 20 issue of the *Rockbridge County News* of Lexington, Va. Quoting its own columns of March 18, 1897, the *News* brings to light the following paragraph:

> Professor S. T. Moreland of the chair of physics of Washington and Lee University gave a lecture on electricity and the Roentgen rays at the Y.M.C.A. building in Lynchburg Thursday night. Those who desired to remain longer than 10 o'clock had the opportunity of seeing an exhibition of the wonderful x-rays when Professor Moreland's little boy Edward was placed before the light and the bones of his body could be plainly seen through clothes, flesh and all.

It is quite possible that Professor Sidney Turner Moreland, absorbed in bringing the latest gifts of science to the notice of his listeners, may have exercised his professional (and professorial) prerogative in absent-mindedly failing to note the hour at which the demonstration took place. In the interests of the advancement of science we may, therefore, overlook the lapse of parental discipline which enabled a juvenile member of the family to postpone bedtime past the advanced hour of 10 o'clock. Besides, if any injury was done, the harm was at best of very short duration.

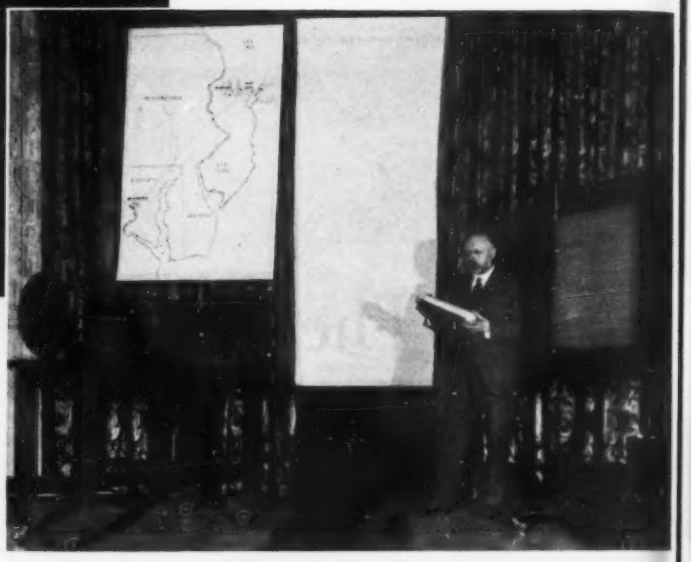
What the *Rockbridge County News* failed to mention, however, is quite as interesting as the above quotation. The *News* might have informed its current readers, for example, that "Professor Moreland's little boy Edward" was destined to receive his master's degree in electrical engineering from "Boston Tech" eleven years and three months after his bones were displayed to the Lynchburg residents. Whether or not parental influence had any bearing on the matter, the *News* might also have informed its present readers that the firm of Jackson and Moreland was formed in 1919 by the Moreland of the second generation in collaboration with one of his M.I.T. professors, and head of the Department of Electrical Engineering, Dugald C. Jackson. Finally, the *Rockbridge County News* might have taken pride in pointing out that one of Lexington's native sons, "Professor Moreland's little boy Edward" grew up to become dean of engineering and later executive vice-president of the Massachusetts Institute of Technology.

Science for the Next Generation

THE current wave of rising costs and the strikes staged by teachers in Norwalk, Conn., Buffalo, N. Y., and in other cities in the United States has focused attention on the dwindling supply of properly trained teachers in the primary and secondary schools throughout the country. Many who, in years past, looked to teaching as a pleasant and respected career have been tempted to leave the classroom for the production line, the laboratory for the shop. To meet the steadily increasing cost of living, in which food prices and wages of labor have accounted for the major rises, still others have had to supplement their pedagogical earnings with whatever additional income could be garnered. Most of the difficulty has been in the elementary schools, although colleges have not been immune from these economic influences in spite of their current heavy enrollment which may be expected to continue for another three or four years.

Dr. Fletcher G. Watson, of the Graduate School of Education at Harvard University, reports that a survey of 18 of the country's largest teacher-training institutions showed that, of 120,000 students in these institutions, only 307 are specializing in science or mathematics. Our civilization is predominately the product of science and engineering. If Dr. Watson's statistics may be taken as a forecast of things to come, only three out of each 1,000 of the dwindling number of persons preparing to teach the next generation will be qualified to properly inculcate the fundamentals of science or mathematics in their pupils.

Historical experimental telecast was made on April 7, 1927, when Herbert Hoover, then Secretary of Commerce, speaking in Washington, was heard and seen by an audience of 700 persons in New York. With Mr. Hoover at this historic event were (left to right): *General J. J. Carty, Vice-president of the American Telephone and Telegraph Company; A. E. Berry, President of the Chesapeake and Potomac Telephone Company; and Judge Stephen Davis, Solicitor for the Department of Commerce.*



Dr. Herbert E. Ives, in charge of the Bell Telephone Laboratories' demonstration of television two decades ago, holds one of the large photoelectric tubes used for picking up video signals. Original laboratory scanning apparatus is at the left, below the map tracing the path of the video and audio signals between Washington and New York. The television screen is at the extreme right.

That Famous Corner

ANTICIPATION is a stimulant. It brings forth the highest hopes, the most optimistic expectations for the future; it colors the drab present with the vivid hues of the morrow. There is, moreover, almost unending fascination in attempts to peer into the future and to determine what manner of thing lurks around the much publicized corner. To quote from an article in The Technology Review:

> We are told that "television is just around the corner." As a matter of fact it definitely turned the corner of physical reality on April 7, 1927, when Herbert Hoover, then Secretary of Commerce, addressed an audience of over 700 publicists, seated in an auditorium in New York City, by means of long distance telephone and television circuits from Washington. The corner which remains is that where the value and cost of obtainable performance meet.

The sentences quoted above do not refer to a postwar resuscitation of the now threadbare prediction that we shall soon have television service in our homes to bring visual supplementation of sporting events, commercial plugs, and serials which, at present, enter the American home daily by way of the loud speaker. They are 15 years old and appeared as part of an article, "Looking 'Round the Corner" by J. Warren Horton, '14, published in The Technology Review of October, 1932. The paragraph is particularly appropriate at the present time not only because we have just passed the 20th anniversary of the first successful demonstration of long distance television communication, but also because the factors which prevented television from turning the corner in 1932 are pretty much those that still make large-scale television broadcasting impractical.

True enough, the 1927 experiments in television by the Bell Telephone Laboratories did not provide images of sufficient quality to be acceptable for widespread use in American homes where emphasis is largely on the entertainment value of the visual medium. But the 1927 experiments were in no way intended to provide a solution for commercial television service; rather were they designed to study the possibility of transmitting the highly complicated television signals over long distance wire and radio circuits. The mechanical scanning methods used in the 1927 experiments were no hindrance for the purpose of research, and if the detail of the 1927 pictures was poor by comparison with 1947 standards, the electrical images transmitted between Washington and New York represented the best that was possible of achievement two decades ago.

Since the 1927 demonstration, progress has been rapid. From a technical point of view television images, comparable in quality to those produced by amateur motion pictures in monochrome, could have been produced at any time within the past decade. Before this country took part in World War II, experimental demonstrations had been made of color television, and projection systems (which were capable of producing black and white images large enough to fill a motion picture theater screen) had been demonstrated to the press in New York. By developing new electronic tubes for use in television cameras, recent research has removed much of the practical difficulty of televising scenes under poor lighting conditions. More recently an all-electronic (*Concluded on page 476*)

Maintaining Student Health at M. I. T.

By Dana L. Farnsworth

THE development of student health service in colleges has been of comparatively recent origin, for up until about 25 years ago most colleges maintained a very small staff of physicians and attended to minor medical matters only. If any illness called for more than routine medication or advice, the student went to a private physician or more often received no treatment. During the past quarter century, however, there has been a growing interest in the field of student health until now most colleges assume that the health of their students is of as much importance as the development of their intellect. Providing students with clinical treatment and hospital care is a worthy part of a student health service but not the most important one. A vigorous student health department should be an educational unit so organized as to show the student and the community how to use medical care efficiently and wisely, so the graduating students may become leaders in their communities in efforts to maintain well-organized public health services, effective sanitation, and a wide distribution of modern medical treatment facilities.

The growth of the Medical Department at M.I.T. may be visualized by comparison of the statistics for the years 1913–1914 and 1945–1946. In 1913–1914 the Institute physician maintained office hours from four to five o'clock on Mondays and Thursdays. During that year he saw 244 students for a total of 562 consultations.

Two dental hygienists are in full-time attendance to provide dental service as an important part of the Medical Department's activities. Complete equipment for two chairs and an x-ray machine are available.

He spent a total number of 62 hours in the clinic. In contrast, in 1945–1946, which was the last year under the directorship of Dr. George W. Morse, the Medical Department had a total of 32,955 calls. Not only had the amount of medical attention changed during the years but the whole conception of the care of the students of M.I.T. had become elevated. The completion of the Homberg Memorial Infirmary in 1928 and its remodeling in 1945 have furnished the setting for much of this growth.

Since 1919 faculty members and employees have been treated on the same basis as students. This year there are 8,300 persons eligible for medical service.

At the present time the Department interest in a student of M.I.T. begins before he enrolls at the Institute. A form is sent to the student to be filled out by his family physician which calls for certain pertinent information about the student which will be of use to the Medical Department in caring for his health needs while in residence at the Institute. From this form we learn whom to notify in case of serious illness, as well as the medical history of the student and his family. We learn whether or not he has had any nervous illness, whether he is subject to fainting attacks and if he is sensitive to any drugs. The family physician is asked if, in his opinion, the student may safely participate in athletic activities. With this information the possibility of inadvertent injury to the student's health during the first few days or weeks of college is minimized.

After he comes to the Institute, the student reports to the Medical Department for an appointment for a

First-Class Facilities and Personnel Are Available When Remedial Action Is Required but Emphasis Is on Maintaining Health

Office and . . . . *Reception Room*

To maintain records for the more than 120 daily clinic consultations requires a staff of seven persons. The pleasant and comfortable reception room encourages students to avail themselves of the many services which are provided by the very well equipped M.I.T. Medical Department.

physical examination. At this time he is asked to fill out a more detailed form, giving his own version of his past medical history, health habits, and his military history, if any. Then the examining physician checks him thoroughly, requests any indicated laboratory procedures, and determines what athletic activities he may be allowed to engage in safely. The student then goes to the Dental Service where a checkup of his teeth is made and appropriate x-rays taken. An x-ray of his chest completes the examination. Thus, within a very few days or weeks after he is admitted to the Institute, the Medical Department has a fund of information about each student's health, which enables it to be of greatest usefulness to the patient in case of subsequent illness. All the accumulated records of each student are kept in a folder which is brought from the files each time a student visits the Medical Department and is made available to the doctor at the beginning of the consultation. Although this is sometimes a useless procedure for very minor injuries or illnesses, yet it does help prevent unnecessary mistakes on the part of the physician. In case the student needs to be admitted to the Infirmary, then his record is transferred to the Infirmary for the benefit of the visiting physician there. During the remainder of the student's career at M.I.T. he receives an x-ray of the chest, a physical examination, or both, each year.

When a student becomes ill and reports to the Medical Department, he is seen either by an internist or a surgeon. The department is so organized at present that there are always at least three doctors in the clinic and sometimes as many as six at any one time. If specialized attention is needed, then the student can be referred to the laboratory, to the x-ray department, or to special clinics in ophthalmology (eye), otolaryngology (ear, nose and throat), dermatology (skin), neurology or psychiatry for the required treatment.

Because of the proximity of excellent Boston and Cambridge hospitals the Medical Department does not maintain a complete operating room for major surgical operations. If an appendectomy or other major operation is necessary, the patient is transferred to the hospital of his own choice, where he may also choose his own surgeon if he so desires. In most instances, however, the student is not familiar with surgical facilities or with the skill of the various surgeons, and as a result he abides by the judgment of the Institute physicians. After his operation has been performed and he is able to be transferred, he is then returned to the Infirmary for the period of convalescence.

When any student contracts a contagious disease, such as measles, mumps, or chicken pox he is transferred to the Haynes Memorial Hospital in Brighton.

The Institute has just completed an arrangement with the Massachusetts General Hospital whereby M.I.T. students may be admitted on an emergency basis to the surgical or medical wards of that hospital and receive adequate care regardless of the financial status of the patient. Thus the parents of any student of the Institute may be assured that modern and skillful treatment is available for their son or daughter as long as he or she is enrolled at the Institute.

Hospital Care

The second and third floors of the Homberg Memorial Building contain 33 beds for the hospital care of students, faculty members, and employees. During the past two years this number of beds has been adequate, chiefly due to the fact that no epidemic occurred during that period. In the event of an epidemic of any sort, emergency facilities are available in the Emma Rogers Room or in space furnished in the building of the School of Architecture.

On the second floor of the Infirmary, which was newly renovated in 1945, there are 19 beds, two of which are in private rooms, two in a two-bed ward, three in another ward and six in each of two others. The arrangement in the large wards is such that the nurse on duty can maintain very close supervision over all the patients by means

One of the best equipped and most frequently used units of the Medical Department is the Kales Eye Clinic, gift of Mrs. Kales in memory of her husband, William R. Kales, '92.

of an ingenious architectural arrangement whereby windows from the nurse's station permit visibility to both of them. The kitchen and dining rooms for the nurses and employees are also located on this floor.

The third floor contains two wards with a total of nine beds and five private rooms. In addition there is an operating and sterilizing room, various utility rooms, and an apartment for the chief nurse. On the roof is a solarium which can house from two to four beds in emergencies, but which is usually used by convalescent patients.

When the clinic on the first floor is closed, first aid and emergency treatment are always available on the third floor. A physician is either in residence or on call at any time day or night throughout the year.

Kales Clinic

In 1946 the Kales Clinic for the diagnosis of diseases of the eye was established by Mrs. Kales in memory of her husband, William R. Kales, '92, who was formerly a very valuable and interested member of the Department's Visiting Committee. In this clinic the ophthalmologist has the most modern diagnostic equipment available, and ever since its establishment it has been one of the Department's most popular and useful clinics. During the present academic year an average of 150 patients a month have had ophthalmological consultations in this clinic.

In January, 1947, the scope of the Kales Clinic was extended to include diseases of the ear, nose, and throat, and suitable diagnostic and therapeutic equipment was installed. One of Boston's prominent otolaryngologists has accepted an appointment to the staff, and he now holds regular clinics two days of each week, in addition to responding to emergency calls.

The two large wards on the second floor are so arranged that supervision is easily achieved from the central location of the nurse's station. The wards, of which there are four, are furnished with the most modern hospital facilities for the comfort of patients, and efficient medical care is provided by a capable staff.

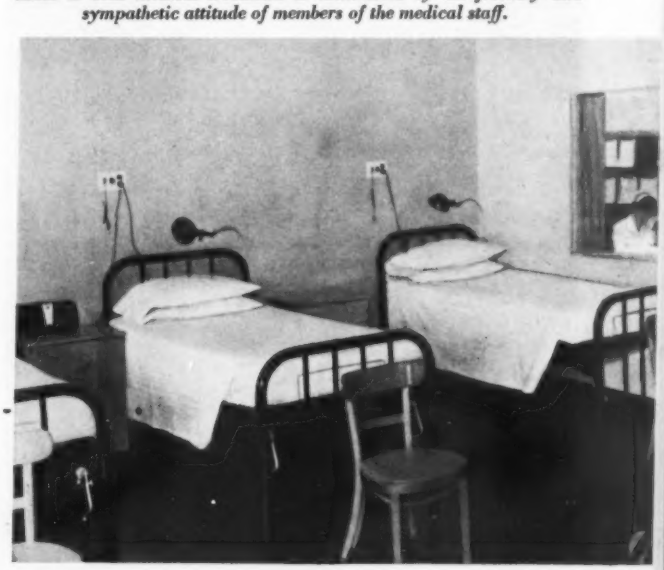
The Dental Service

Ever since its establishment by a grant from the Charles Hayden Foundation in 1940, the Dental Service has formed an invaluable part of the Institute health facilities. A dentist holds a clinic for one hour each day and two dental hygienists give full-time duty. Some indication of the scope of their work may be learned from the fact that during the first half of the present school year there were 2,582 visits for examination and treatment and 1,301 x-rays were taken. Only diagnostic, emergency, and prophylactic work is done in the clinic; if complicated mechanical treatment is needed, the student is referred to a private dentist.

Psychiatric Service

From the administrative standpoint it is convenient to think of the student in an abstract way and to assume

Miss Alice M. Browne assists Dr. John W. Chamberlain, '28, in giving emergency treatment to a student in the first-aid clinic. Reluctance to seek medical treatment is minimized by the friendly and sympathetic attitude of members of the medical staff.



that he should enroll in college and attempt to do the work required of him. If he is unable to pass his courses, then he should be dropped and someone else admitted to take his place. In fact, some administrators have expressed the idea that a good admissions officer can eliminate psychiatric problems by the simple expedient of not admitting potential neurotics. This concept overlooks the fact that every person is a potential neurotic and that whether or not disabling symptoms ever occur depends on a large number of variable circumstances. Experience with combat casualties during World War II convinced the writer that every man has his breaking point; that up to a certain point a person performs his duties in a satisfactory, highly integrated manner, but when the strain becomes too great the formerly well-adapted individual "goes to pieces" and is greatly handicapped by a multiplicity of symptoms. The sources of strain are usually numerous and varied and cumulative in action; the symptoms are apt to be abrupt and dramatic, and frequently appear to be brought about by a trivial occurrence.

The more highly skilled and sensitive a person is, the more vulnerable he is to factors of stress and strain in his environment. Successful training and the acquisition of skills and habits in a specialized field tend to counteract the tendencies toward neurotic behavior. The student, however, is frequently bewildered and perplexed by the numerous demands made on him before he has made a mature adjustment and may respond to them in a highly inappropriate manner. Hence the physician who is interested in emotional problems has the most favorable opportunity of any life period when he attempts to aid the college student in the solution of his problem.

Students at M.I.T. have problems confronting them which are very similar to those of college students everywhere in the United States. Some have to contend with insecurity at home because their parents are separated or display open hostility toward each other. Others feel hopeless in the attempt to make a record as good as that of a brilliant father. An occasional student has difficulty in reconciling his religious beliefs and the scientific facts that he has learned. Sex problems interfere with the efficiency of some students. A brilliant student may develop faulty study habits early in his college career, acquire a false sense of security because of the ease with which he secured good grades during his first year, only to find later on that he has reached a crisis — is about to fail — all because he is unable to think through his problem alone. The influx of married students has brought the usual quota of domestic disharmony, especially since many couples are trying to adjust to each other under conditions which are trying at best. All these and many other types of problems are tackled by the psychiatric staff of the Medical Department with the idea in mind that it is much more worth-while to help an already highly skilled student make a better adjustment than ruthlessly to cast him aside and make way for a person who has not yet developed any symptoms. Over a 12-year period the writer has seen enough successes in psychiatric treatment of college students to warrant the conclusion that this work is of vital importance in any student health organization. It is, essentially, psychiatry for the normal person, and, as such, is of great educational significance for the whole community as well as for any individual.

Temporary x-ray equipment set up by the Massachusetts State Department of Health during April enabled more than 4,000 students, employees, and faculty members to have chest x-rays made at the Institute.

Co-operation with Dean's Office

There is a close working relationship between the Medical Department and the Dean's Office, since many problems that students present must be worked out jointly by the two offices. The Dean of Students is a member of the Medical Department and, as such, attends staff meetings and is always aware of the policies and procedures of the medical staff. Care is taken, however, to see that the privacy of the student is not violated, and all medical facts are held in strict confidence. In no sense is the Medical Department a participant in passing on to the Dean's Office information about a student which might prove embarrassing to him. To do so would be a violation of the traditional confidence which is an essential part of the physician-patient relationship and would seriously limit the usefulness of the Medical Department in various ways.

Practically all cases of low scholarship are reviewed by the Medical Department before final recommendations are made by the dean to the Faculty in order that remedial measures may be taken if any health factor is present.

In the broad field of student morale and the promotion of mental health the deans and physicians are frequently quite dependent on one another. Very frequently disciplinary problems turn out upon investigation to be largely in the emotional field and hence require medical skill for their solution. Likewise, numerous strictly medical situations can be handled only by the sympathetic understanding and co-operation of the deans. The whole philosophy of the two departments, both in theory and practice, is one of complete co-operation in all matters affecting the welfare of students.

Health Supervision of Athletes

In addition to performing a complete physical examination on each student before he is allowed to participate in any athletic contest, a physician (*Continued on page 478*)

The Scientific Way

Practical Application Often Results from Pursuit of the Scientific Way, but the True Aim of Science Is the Advancement of Knowledge.

By Vannevar Bush

In the hurry and bustle of our crowded and complex daily life, we all too easily become engrossed with immediate things to such an extent as to lose sight of lasting things. Hence we run a great danger, for unless we maintain the balance that comes from awareness of the basic reasons for action, we may become as futilely frantic as the squirrel on a treadmill or the rat in a maze.

It is from the point of view of these considerations that an inquiry into the scientific way may be made. Since I am, of course, an electrical engineer, such an inquiry as I may make reflects primarily the point of view of an engineer. It is fitting enough for an engineer to examine into science, however, for engineers and engineering depend upon science much as medical practitioners do, or much as the weaver both depends upon and fosters sheep raising, or the publisher is both the servant and the sponsor of literature.

The human being has four great sources of strength on which to draw for the energy which he puts forth in carrying on the varied activities that go to make up civilization and thus serve to distinguish mankind from other forms of life. They are his reason, the exercise of which finds clearest expression in law and science; his imagination, whence spring art, music, poetry; his physique, mastery and skilled utilization of which reaches consummation in the ballet and in sports; and his spirit, out of which grow the lofty conceptions of philosophy and the noble aspirations of theology and religion. Almost anything that man does, of course, calls to some extent on all four of these wellsprings. Certain groups of activities, however, draw more heavily on one of these.

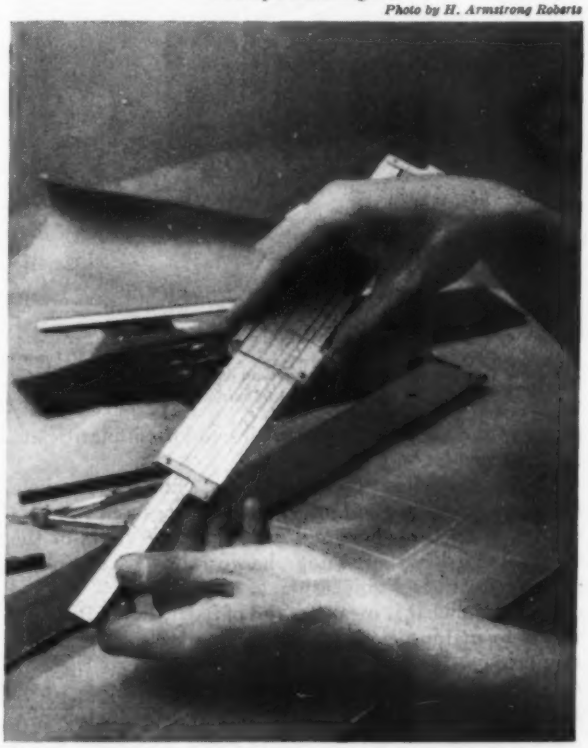
In science, the great draft is on reason. Naturally imagination contributes in the building of a theory and in devising experiments to test its validity. Sometimes the physique is placed under heavy toll, particularly for adroitness, steadiness, and dexterity in the assembly and use of apparatus and for reserves of stamina to meet the strain of long concentrated work. It can fairly be said, too, that spirit — maybe simply intuition, possibly something greater and more significant — often has in the work a part which is real and which can be sensed and recognized, even though it cannot be easily defined.

Method of Science

But science, research, the scientific way, place the greater draft on reason. To follow this way demands at the outset a consistent willed effort at concentrating the analytical powers of the intelligence to classify and so to assimilate the necessary and sometimes very large body of existing knowledge. It demands then a different but equally delicate type of analytical skill to study the mass of knowledge thus accumulated, in order to discern gaps. Once a gap has been discerned and defined — this is another way of saying once the need and opportunity for research with a specific objective have been discovered — there must come into play a further sort of questioning thought. The possible ways of filling the gaps must be surveyed and evaluated, and the right selection must be made from among them. When procedure has thus been decided upon, the various steps in applying it must be planned, and the performance of the steps must be controlled. At last, when result has been achieved through these operations, the investigator is faced with the sometimes confusing and always exacting task of assessing his findings, relating them to the problem which he sought to solve, and determining whether they actually do solve it or whether they are deceptive and must therefore be

In nearly all its aspects, our culture relies upon machines, implements, instruments, techniques, and processes which have developed from scientific knowledge.

Photo by H. Armstrong Roberts



abandoned, no matter how much long and arduous work they represent.

What I have just sketched are of course not the only stages by which one travels the scientific way. There is a reverse course, of equal importance and of equal difficulty, which one often takes and which makes comparable demands on reason. This occurs when a new fact is apprehended as new, that is, when the investigator realizes that he has, in the process of an undertaking, encountered a phenomenon which is an addition to knowledge. To make this realization (to recognize the new as new when it is first met) demands an alertness of mind, a freshness of vision, which are maintained only by deliberate effort. It is perilously easy for man to go through his daily routines almost automatically and thus to relax his vigilance and let his responsiveness to events become atrophied. The follower of the scientific way who guards against this peril, however, and hence who knows when he has come on a new thing, vigorously exercises reason thereafter, to define the new fact, to limit it, and to distinguish and explain its similarities and dissimilarities to older known facts.

Photo by Harold M. Lambert

The trend . . . has been steadily toward an easier and richer life for the ordinary human being.

Thus his effort is to relate the new thing to the whole body of knowledge, finding where it belongs and what its bearing is on the whole and on the several parts of the whole. As he does these things, he works toward establishing the intrinsic signification of the new fact, toward determining what it means in and of itself. In addition, he works to making clear and understandable its extrinsic significance. He traces out the ways in which the new addition to knowledge illuminates other matters which have hitherto been obscure. He contributes to the ultimate formulation of answers to other problems which have not yet been brought to solution, and so increases the homogeneity of knowledge as a whole.

Now clearly, the intense joint application of the will and the intellect which is involved in following either of these courses along the scientific way, is no child's play. It is exertion of the most exacting sort. It is, in truth, plain hard work. There are a lot of easier ways of earning a living, and sometimes a more comfortable living in the material sense, than is the usual scientist's lot. Then why do scientists pursue a harder road than some of their contemporaries? Inquiry into some of the many reasons for their action will contribute substantially to understanding of the scientific way. In such inquiry, we may leave out of account the practical necessities of earning a livelihood. They apply with almost equal force to most if not all men, and hence have no special bearing on men's motives in making one or another choice of career. The question hence is found fairly sharply. What are the special satisfactions, the special obligations, of the scientific way?

Satisfaction of a Task Well Done

As is true of any human activity which is carried on with full vigor and full sincerity, a basic motive, which for many people is by itself sufficient, can be found in the individual personal aesthetic satisfaction which comes from doing a thing well. This is the reward of self-sufficient virtuosity. Just as the virtuoso of the imagination can consider the phrase "art for art's sake" an all-encompassing answer, so the virtuoso of the reason may declare "reason for reason's sake" or "science for the sake of science" cause enough for his doing what he does. Think of the fly-fishing enthusiast who rigs his tackle and solemnly casts and casts again on dry land, sheerly for the zest of doing a difficult thing with all the skill at his command. This joy of the virtuoso, this satisfaction of the connoisseur, is one of the most powerful incentives; it has probably been a principal motivating force in many independent investigations in the most abstract and recondite subjects. I have no doubt that it meant much to Leonardo, to Newton, to Count Rumford, to Lowell. I doubt not that it means much to many among our contemporaries, and therefore is productive and vital in the expanding progress of science in our time. It demands a mind strong enough to avoid becoming precious, to avoid taking the position of the scientist who is reported to have boasted of his pride that, as far as he could determine, no conceivable use attached to anything he had ever done in research.

At the extreme from this remark (which really sounds too ivory-domed even to come out of an ivory tower, let alone an ivory laboratory) is the view that the practical usefulness of the results of research is reason enough for a man to enter upon science as a career. The argument runs that most research, most scientific endeavor, is undertaken primarily in order to produce immediate practical utility. It is true enough that the practical uses of the knowledge gained through scientific research bulk very large indeed in our civilization. In nearly all its aspects, our culture relies upon machines, implements, instruments, techniques, and processes which have developed from scientific knowledge. It relies upon them to a greater extent than has ever been true before, to such an extent that we plow and cultivate science as the Romans plowed and cultivated their fields. (*Continued on page 482*)

Engineering and Education

Some Thoughts on the Education of Engineering Students to Prepare Them to Assume Positions of Leadership in a World of Increasing Technology

By Robert G. Caldwell

THE central theme of higher education in our time is the conquest of nature for the comfort and convenience of man. To some a statement of that kind will seem entirely natural and proper. To others it can only appear deeply shocking. For the frank acceptance of such an analysis places engineering studies in the central stream of educational development and relegates many other subjects to the margins. But whether the trend is good or bad, the evidence for its existence is readily available to the thoughtful.

If one reads books on educational theory and objectives only, it would be easy to prove by quotations that higher education is not actually passing through any such revolution. The real evidence is to be found in other ways — in the published catalogues of our colleges and universities, with their increasing list of scientific and technical subjects, and in the quest of boards of trustees for presidents who have won their spurs as scientists, physicians, and engineers. It is to be found in the applications from students in foreign countries, the great majority of whom desire to come to America to learn the new techniques which played so large a part in World War II and which in any case will give to other countries new navies, as in Turkey; new industries, as in Brazil; or a new agriculture, as in China.

Or, consider the letters from young veterans who want to complete an interrupted education with the help of government funds. Almost without exception, these young men and women desire an education which will help them, as soon as possible, to make a living. Where imagination has been aroused, or intellectual curiosity sharpened, it is often with regard to the apparently unlimited present opportunities of applied science.

To try to turn the stream in any other direction probably would be unwise and certainly futile. An increasing number of our educated men will be devoted (either as scientists or as administrators of business and government enterprise) to a deeply felt, if only half-expressed, purpose, namely, to conquer nature for the increasing comfort, convenience, and power of man. If this be so, engineering, broadly defined, is no longer a side show but the chief performer in the main tent.

It need scarcely be said that man's conquest of nature spells revolution, for this objective has but recently become the central theme of education. The meaning of education has always been the most exciting subject of human discussion. It could not well be otherwise, for the meaning of education is nothing else than the meaning of life, of which it is not so much a preparation as an integral part. Each age has reached its own idea of the purpose of education.

Thus, presumably, the Greeks sought wisdom, the ability to choose the good life, the development of critical insight, and Socrates could say: "The unexamined life is not worth living." Almost as clearly, the Romans sought civic virtue, the preservation of those habits of thought which created an empire. "What can the individual contribute to the state?" asked the Romans, or "How can he make a state worthy of the individual?" Later, in the Middle Ages, when the older empire had disappeared and new states had not yet appeared to which men might devote loyalty and allegiance, emphasis changed to the

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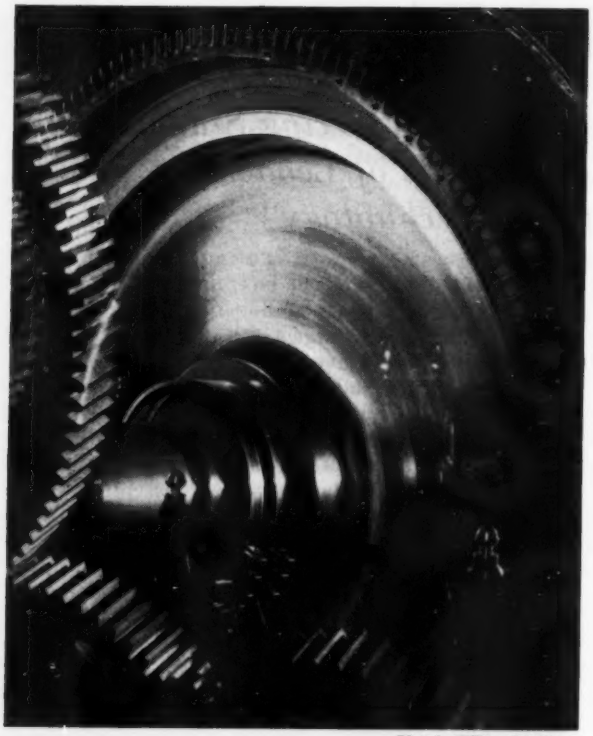


Photo by William M. Rittase

It need hardly be said that man's conquest of nature spells revolution, for this objective has but recently become the central theme of education.

discipline of the individual in an evil world. Such emphasis resulted in the development of the liberal arts, chiefly language and mathematics. It brought forth the trivium and the quadrivium by which, at very worst, the individuals might be more ready for a better world beyond the stars. Then came the rise of cities, the invention of printing, the discovery of America — in fact, the whole movement we call the Renaissance.

Danger of Emphasizing Applied Science

And now today, as a result of a whole series of industrial revolutions, spread over 200 years and over 50 countries, not only the content but the very heart of education is changing once more under our eyes. In reality, whether in theory or not, the large endowments, as well as the most ambitious students, are increasingly devoted to a new objective — the conquest of nature for the comfort and convenience of man. We may overcome disease by medicine, or space by aeronautical engineering, or we may produce new foods by chemistry. In any case, the objective is man's supremacy over, and control of, nature. If you doubt the trend in this direction, read those unphilosophical documents, the college catalogues and the enrollment applications in science courses, or listen to educational directors of large companies on radio programs.

The new emphasis on applied science, however, conceals dangers to the individual and to society. It has even practical disadvantages which have not gone entirely unchallenged. Thus, the head of a great industry, himself a distinguished engineer, wrote in a recent letter that he hesitated to employ graduates of technical schools — or at least to give them genuine responsibility — until an inadequate education had been completed and integrated with other ideas in the school of experience.

Similarly, Sir James Alfred Ewing wrote in 1928: "I used, as a young teacher, to think that the splendid march of discovery and invention, with its penetration into the secrets of Nature, its consciousness of power, its absorbing mental interest, its unlimited possibilities of benefits, was in fact accomplishing some betterment in the character of men. I thought that the assiduous study of engineering could not fail to soften his primitive instincts; that it must develop a sense of law and order and righteousness. But the war came, and I realized the moral failure of applied mechanics. . . . I saw that the wealth of products and ideas with which the engineer had enriched mankind might be prostituted to ignoble use. . . . The arts of the engineer had indeed been effectively learnt, but they had not changed man's soul. . . . Does it not follow that the duty of leadership is to educate his judgment and his conscience? . . . Surely it is for the engineer as much as any man to pray for a spiritual awakening, to strive after such a growth of sanity as will prevent the gross misuse of his good gifts. For it is the engineer who, in the course of his labors to promote the comfort and convenience of man, has put into man's unchecked and careless hand a monstrous potentiality of ruin."[1]

Very recently, in considering a report of a committee to study engineering education after World War II, Robert F. Leggett made the following comment: "May I therefore presume to suggest that before the Report is broadcast throughout the land and finally placed in our records, a few more words might be added — words which will suggest that the young men we are to train should be helped to lift their eyes beyond the confines of one country, even of a very great country, looking rather towards the welfare of the community of nations as a whole; words which will help us to beware of the insidious attraction of current catch phrases in matters both academic and social, and to rely rather on the things which are true and of good report, words which will show that engineering educators do have a fine sense of values and one which may therefore help us to do our small share in trying to ensure that the works of our students shall not again be prostituted to ignoble use."[2]

All this reminds us of what Montaigne said in the Sixteenth Century: "Human society goes very incompetently about, healing its ills. It is so impatient under the immediate irritation which is chafing it that it thinks only of getting rid of this, careless of the cost. Good does not necessarily ensue upon evil; another evil may ensue upon it, and a worse one."

In our day, H. G. Wells went even further: "If man does not adjust himself very soon to the changes his inventions have wrought in his environment, he will become one with the dinosaur and the marmota, who in the changing world of their days could not readjust themselves quickly enough to make the grade."

The increased emphasis on applied science and the correlative acceptance of a new theme in education are, of course, a general feature of higher education and are

[1] Sir James Alfred Ewing, "A Century of Inventions," *Engineering*, Vol. 125, Nos. 3256 and 3257 (June 8 and 15, 1928), pp. 709–711 and 755–756.

[2] *Engineering Education*, 52:51.

certainly not limited to engineering colleges as such. Thus, for example, there is an increasing tendency for premedical students to devote a large part of their time as undergraduates, and an even larger share of their interest, to subjects directly related to later professional courses.

Uniqueness of Engineering Education

In one respect, however, the engineering colleges are in a unique position; they have direct contact with students throughout all of their academic training for a professional career. Engineering is the one great profession in which the majority receive training in a typical four-year college course, leading to such degrees as bachelor of science in electrical engineering, and others of like character. More than nine-tenths of American engineers go no further. Only a limited number find, sometimes after a few years in industry, that they need additional training at the graduate level to fit themselves for research in pure or applied science. Hundreds of graduates of technical schools, however, use their undergraduate training for general purposes only, and after a few years find their real vocation in general administrative or executive posts. In other words, the engineer is first a human being with wide needs and aspirations; he is also a citizen who may contribute much to the community. But, more important, he is a potential leader of men with a need of a fine sense of values, interests, and skills other than those which apply primarily to the great profession of which he is a representative.

The educational dilemma thus presented is not resolved, however, by an easy division of all studies between those that are scientific, and therefore professionally useful, on the one hand, and others which are variously denominated liberal, humanistic, or general, on the other.

All of the better engineering colleges now devote a very large proportion of their time to so-called pure sciences which are obviously basic to engineering techniques. These latter are increasingly postponed, not to say relegated, to the graduate school, or, in increasing degree, to the necessary period of apprenticeship in industry. It is, of course, this very factor which distinguishes the fundamental training of the engineering college from the important but different, and usually less rigorous, practical training of the trade school.

Now in a large measure, training in science with a view to later training in applied science is certainly liberal in the sense that new windows are opened and new interests are created. Similarly, the sciences are essentially humanistic. Once, perhaps in the middle of the Nineteenth Century, one could think of man with his dreams, hopes, and aspirations quite separate from nature with her rigid framework of mechanistic laws. That, surely, is no longer possible. We now see, as clearly as Plato or Bishop Berkeley might have done, that science is merely a great, perhaps the greatest, instrument of the human mind to help answer human questions and to resolve human problems. In other words, even in an age of increasing specialization, we come to the point where traditional and convenient distinctions between natural and social sciences, or between science and humanities, disappear.

For both practical and theoretical reasons, therefore, we cannot take care of general education first, in school or in a year or two of liberal arts, and then come to what is really interesting and contemporary. Young men rebel, and rightly so, when told that they must postpone the elementary study of pure and applied science. They rebel even though the chosen few may readily carry their fundamental studies into a later intensive period of advanced study in the graduate school.

Signposts and Landmarks

For reasons of this kind, both the engineering profession as a whole (speaking through representative committees reporting in 1940 on the trend and scope of engineering education, and in 1944 on engineering education after World War II) and the engineering colleges and universities themselves have come to the almost unanimous conclusion that the four-year course in American engineering colleges has come to stay.

A substantial part of the time, expense, and effort of four-year engineering courses must be devoted to studies which have not been regularly regarded as part of the engineering curriculum. Such nonengineering studies do not aim at a second and different education, but are a

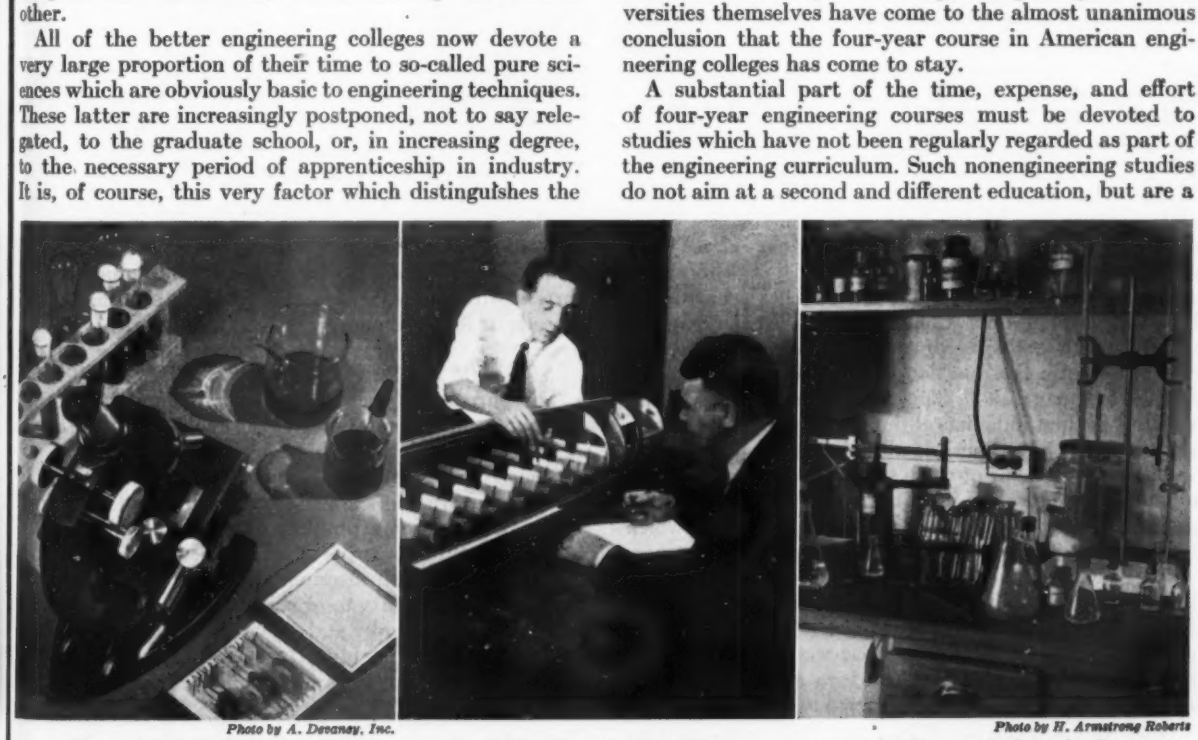


Photo by A. Devaney, Inc. — Photo by H. Armstrong Roberts

We may overcome disease by medicine . . . or space by aeronautical engineering . . . or we may produce new foods by chemistry.

Photo by Chester H. Pope, '09

The important thing is a sense of perspective which comes from studying the past, and a realization that the world was not created in the year 1900.

part of one and the same education looked at from the point of view of citizenship and life.

Back in 1924, *The Atlantic Monthly*[3] published an essay by the late Lord Moulton, celebrated English jurist, entitled "Law and Manners." Life, according to Lord Moulton, has two obvious divisions. First comes the realm of law, controlled by fixed principles, within the jurisdiction of the organized state. On the other extreme is a realm of freedom, in which each individual is at liberty to choose his own path. Between the two lies a narrowing but still enormous area which may be called the realm of manners. Here action is controlled by duty, public spirit, and good taste; the question is not: "What can I do?" but "What may I do?" This is a realm of values within which it is the fundamental duty of education to set up signposts and to establish landmarks.

The establishment of these signposts and landmarks is obviously an enormous job. It is a task which should begin in the homes with our earliest training and of which only a small part belongs to formal education. But academic education must do its part and contribute whatever it can. After all, there is something easy to recognize but hard to define which we may call character. In a democracy, the future of free enterprise depends on character; on character depends the future of free institutions, and of international and social peace.

[3] Lord Moulton, "Law and Manners," *The Atlantic Monthly*, 134:1 (July, 1924). Reprinted in July, 1942, page 31.

A committee of 21 engineers, which has studied engineering education since 1939, has agreed with surprising unanimity on three debatable points: (1) Subject matter which is not essential can and should be postponed. (2) Without detriment to undergraduate professional objectives, approximately 25 per cent of each student's time can be devoted to nonengineering studies to provide a background of general and cultural education. (3) Studies in the humanities and social sciences should proceed concurrent with studies in scientific subjects, and should not precede or follow them.[4]

The Pleasure of Cultural Pursuits

The purposes of such a program are manifold. It aims to provide an understanding of the evolution of the social organization within which we live, and of the influence of science and engineering on its development. It should develop the student's ability to recognize and to make a critical analysis of a problem involving social and economic elements, to arrive at an intelligent opinion about it, and to read with discrimination and purpose toward these ends. The ability to organize thoughts logically and to express them lucidly and convincingly in oral and written English is another objective. Certainly we may expect the well educated to have (*Continued on page 490*)

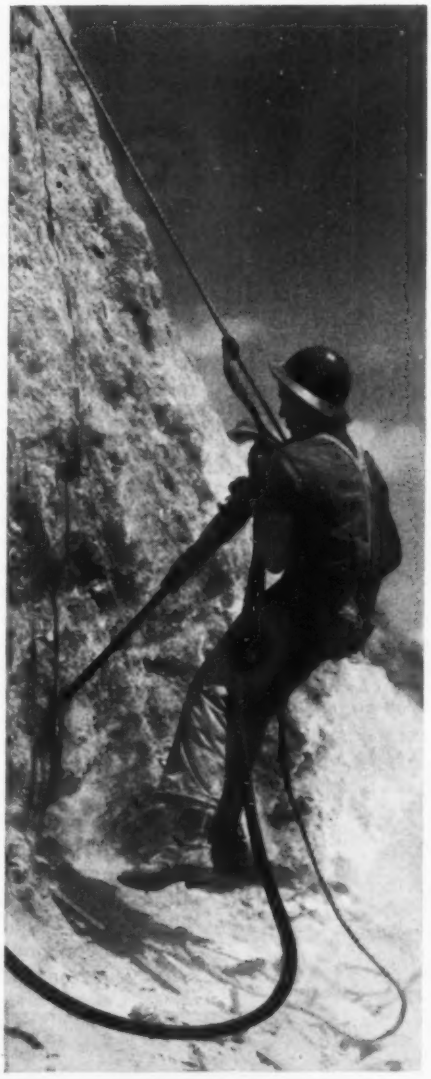
[4] H. P. Hammond, *et al.*, "Report of Committee on Aims and Scope of Engineering Curricula," *Journal of Engineering Education*, 30:555–567 (March, 1940).

Man as a Geological Force

By Paul Cohen

At His Current Rate of Engineering and Agricultural Operations, Man Is Reshaping the Earth's Surface Vastly More Quickly than Nature.

WHEN the geologists discuss the forces which are changing the contours and nature of our planet's surface, they generally give first place to the erosive and chemical action of water. Every year the rivers of the earth carry down to the sea some two cubic miles of debris. That this is no geological trifle is demonstrated by the fact that volcanic action, a secondary but still titanic earth-building force, is estimated to have pushed out on the earth's surface about 500,000 cubic miles of rock [1] during the entire period of our present geological era, the Cenozoic, an era that has already extended for at least 50,000,000 years, though it is the shortest of the periods into which the earth's history has been divided. For a more easily grasped yardstick, we can use our own Mississippi, which annually transports to the Gulf of Mexico in suspension, in solution, or by rolling along the bottom some 600,000,000 tons of material. Because the basin of the Mississippi is so vast, contains so many different types of rocks and has such a spread of climate and rainfall, the rate at which its level is being lowered, about a foot every 5,000 years, may be considered fairly representative for the earth as a whole.[2]



We are currently disturbing probably twice as much earth and rock as American rivers are carrying down to the sea.

It is hardly likely that these figures will cause any staggering reaction to the reader. We have been conditioned to regard such processes as being inherently so diffuse, massive, and on such a huge scale that they cannot fairly be compared to the operations of man. They are akin to the distances of interstellar space, something to be regarded in humble awe (that is, until challenged by the promise of controlled nuclear energy).

What is one to say, then, to the cold statistic that the miners of this country are currently removing more coal from the soil of the United States than the Mississippi is carrying sediment into the sea? To be more specific, the figure for 1944 was 683,700,000 tons of bituminous and anthracite coal. If we also include other ores and minerals, and the amounts of earth and rock that must be moved to get at them, the total weight of material handled yearly in the course of mining operations is well in excess of 1,500,000,000 tons. Operations associated with the construction of airports, dams, roads, and other engineering works are not included. By mining alone, we are currently disturbing probably twice as much earth and rock as American rivers are carrying down to the sea.[3]

Considering the specific gravities of the materials involved, it appears that (again for this country) mining operations result in the removal of about one-quarter of a cubic mile of minerals per year. For the world as a whole the figure is at least two or three times larger. This is a geologically significant amount by virtue of brute volume, let alone because of the changes it implies in the concentration and location of certain key minerals in the crust of the earth.

England, once the world's source of tin, is now substantially devoid of that metal. Cradle of the industrial revolution and creator of an empire that rested on foundations of steel and coal, that island is now stripped of substantially all high-grade iron ore reserves. Many of her choicest and most easily mined coal seams are gone. Her blast furnaces are now fed either by "inexhaustible" foreign mines or by lean domestic ores that must be treated at extra cost before their reduction in the furnace. This is iron of which we are speaking, the fourth most common element and the second most common metal in the earth's crust. As for our own well-favored land, the near exhaustion of our high-grade iron ores in the Great Lakes region is now an accepted situation. Secretary of the Interior Krug has endorsed the St. Lawrence seaway as an economic cushion against the time "when present ores decline and foreign ores are imported." That the time is soon is indicated by the Bethlehem Steel Corporation which is preparing to spend tens of millions of dollars for the development of iron ore

[1] William J. Miller, *An Introduction to Physical Geology*, page 300 (New York: D. Van Nostrand Company, Inc., 1924).

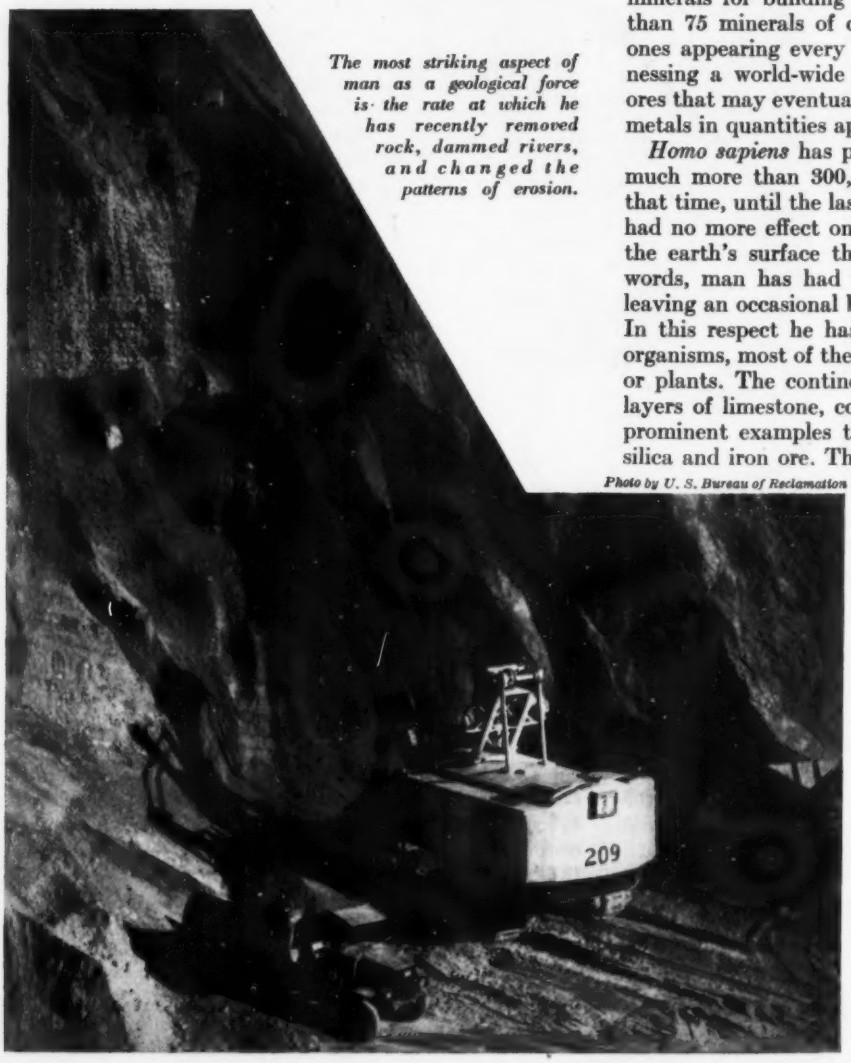
[2] *Ibid.*, page 153.

[3] *Ibid.*, page 153.

properties and handling means in Latin America, in anticipation of large importations within a year.

American history, short as it is, is already studded with once fabulous names — among them, the Comstock Lode, the Tombstone district, the Lake Superior copper region in Michigan, oil fields in Pennsylvania, Ohio, Texas, and California — that are almost, or totally, exhausted as far as present mining techniques are concerned.[4] There is a persisting tendency for a relatively small number of elements, most of them metals selected with little reference to their abundance in nature, to be extracted from their ores and thereafter be maintained in a substantially pure form. A metropolis, such as New York or London, with its associated transport system and industrial plant, represents a concentration of iron, copper, lead, and zinc that rivals or exceeds in content the largest mines. Moreover, the metal deposits in such cities continue to grow whereas simultaneously the accessible ore deposits, starting with the richest, are depleted. There are few, if any, mines outside of the Rand district in South Africa that contain more gold than the vaults at Fort Knox. To consider an aspect that is probably even more important than mining, that is, man's habit of turning forests into farms and grasslands into deserts, it has been declared recently that Alaska is now "about the only place on the American mainland" which can support newsprint or kraft paper development on what is termed, by industrial time scales, a permanent basis.

[4] C. K. Leith, J. W. Furness, Cleona Lewis, *World Minerals and World Peace*, page 88 (Washington, D. C.: The Brookings Institute, 1943).



The most striking aspect of man as a geological force is the rate at which he has recently removed rock, dammed rivers, and changed the patterns of erosion.

Photo by U. S. Bureau of Reclamation

Although such items may be multiplied indefinitely, the most striking aspect of man as a geological force does not reside in the quantity of rock he has sifted, the rivers he has dammed, or in the erosion patterns he has changed through agriculture and deforestation. Rather it is in the extraordinary rate at which he has been doing these things lately, and in the signs that this rate may be still higher in the future. The world has done more mining in the last 40 years than in all preceding history.[5] Lead was being used in counterfeit money before 2000 B.C. and zinc has been known in metallic form since 1520. Yet it is estimated that almost half the lead and about 55 per cent of all the zinc have been mined in the past 25 years. When the Middle Ages ended, about the only materials mined in any quantity were gold, silver, mercury, iron, copper, lead, tin, precious stones, and a few nonmetallic minerals for building purposes.[6] Today there are more than 75 minerals of commercial importance, with new ones appearing every few years. Currently we are witnessing a world-wide search for uranium and thorium ores that may eventually result in the extraction of these metals in quantities approaching those for copper.

Homo sapiens has probably not been in existence for much more than 300,000 years. For the great bulk of that time, until the last 10,000 years at the most, he has had no more effect on the appearance and character of the earth's surface than any other mammal. In other words, man has had virtually no effect at all beyond leaving an occasional bone or chipped stone behind him. In this respect he has been far behind many humbler organisms, most of them single celled creatures, mollusks or plants. The continents are ribbed and spotted with layers of limestone, coral (to mention some of the more prominent examples that are biological in origin), and silica and iron ore. There would be no coal mines or oil fields were it not for once living tissue. Against this great web of once organic rocks that leaves scarcely a portion of the earth untouched and is sometimes mountain high (for example, the Dolomites of the Tyrol, built up of the limestone skeletons of sea organisms), man's efforts are noticeable only with careful scrutiny. But this biosphere has been created over a period of time so long that, by comparison with the duration of recorded history, it sometimes seems to be equivalent to infinity. An illustration may make this statement clearer.

[5] *Industrial and Engineering Chemistry*, November, 1943, page 1131.

[6] Alan M. Bateman, *Economic Mineral Deposits*, pages 368, 525–526 (New York: John Wiley and Sons, Inc., 1942).

Because it takes about 10,000 years, under proper conditions, to build up a layer of coal one foot thick, it must have taken from about 1,000,000 to 2,500,000 years at least to produce what are now the anthracite beds of Pennsylvania.[7] That was about 200,000,000 years ago. Then came folding and faulting, erosion, and the wear and tear of several geological periods. Only about five per cent of the original deposits survived to the present era.[8] To these events man has added an emphatic footnote by mining one-third of the remainder in less than a century. If we continue our present rate of consumption, it will all be gone in another 165 years.

Since anthracite is the rarest and the most desirable of the various ranks of coal, it might be thought that this is an extreme case. Even if all grades of coal are considered, however, including our tremendous reserves of lignite, extraction at present rates would exhaust our supplies of solid fuel in about 2,500 years — geologically speaking, in the twinkling of an eye. As competitive sources of energy arise and as economic conditions and the general state of society command, these rates of consumption will undoubtedly change. Specific figures such as these are not advanced as prophecies or as arguments for conservation. They are merely some quantitative data on the manner in which man is currently disturbing the geological *status quo*.

The phenomenon is world wide. Long before the oldest geological era that can be dated by fossil remains, a great system of gold-containing reefs called the Witwatersrand was deposited in South Africa over an area that is at least 180 miles long, 90 miles wide, and about five miles thick.[9] Massive as is this system, it gives no promise of being immune from eventual exhaustion. Some of the richer and more accessible ore bodies have been mined for the past 60 years, no more than an average man's lifetime. In that period, close to one and a half billion tons of ore (yielding a minute 10,000 tons of gold) have been hoisted to the surface, some of it from depths of almost two miles. The largest air-conditioning plants in the world now alter the climate in the deepest bores to the point where it is endurable. Underground shafts and tunnels have been extended until in the aggregate they rival the earth's axis in length.[10]

Referring again to the mineral fuels, which are extracted in far larger quantities than any other minerals (although carbon is about the fourteenth most common element in the earth's crust), the total combined production of coal and petroleum is currently in excess of 2,000,000,000 tons per year. This amounts roughly to one ton for each of the world's inhabitants, or about 15 times their average body weight. If this ratio is not considered sufficiently fantastic, a more impressive figure may be obtained by considering the per capita output in a heavily industrialized country.

The weight of coal mined and oil produced in this country exceeds by a factor of perhaps 1,000 the weight of pure copper produced. But this comparison is not entirely valid, for as with many other valuable minerals, the weight of the pure product is an almost negligible fraction of the total weight of rock that is blasted, transported, crushed, and winnowed to get that product. In 1944, the average yield of copper for ores mined in this country was 0.96 per cent, less than one part in a hundred. Copper, which constitutes about 0.01 per cent of the earth's crust, is not regarded as a particularly scarce material, and certainly not as a precious one. Where a material of really great value in man's eyes is concerned we may have a situation such as that at the Alaskan Juneau mine where the dredges must pick up, on the average, some 800,000 pounds of sand and gravel to obtain one pound of gold.

The reservoir behind Boulder Dam acts as a huge silt trap for the Colorado River so that below the Dam the Colorado now runs clear.

Less dramatic, perhaps, but just as important as the miner's drill, have been the ax and the plow. Mining tends to cause irreversible changes in the earth's crust, it is true, while forests and prairies will re-establish themselves, if permitted, and new soils can be created from the base rock if times running into the thousands of years are considered. But, in the meantime, accelerated erosion has created a pattern that would not have existed had not the hand of man interfered. A recent newspaper dispatch from Costa Rica can serve as a summary. In passing through that country, the Pan-American highway (which now stretches from Alaska to Patagonia with few interruptions and is something of a geological phenomenon in itself) must cross a highly mountainous and formerly inaccessible region. As soon as the road was completed, however, the natives fell upon the century-old trees and began to convert them to charcoal, which could be brought to market by the same road. Says the dispatch: "Erosion will join the charcoal burners in completing the picture of desolation." Eventually, no doubt, a cycle of conservation will be inaugurated. It has happened before. One of the great- (*Continued on page 486*)

[7] William J. Miller, *An Introduction to Historical Geology*, page 167 (New York: D. Van Nostrand Company, Inc., 1942).

[8] Bateman, *op. cit.*, page 637.

[9] Bateman, *op. cit.*, page 441.

[10] *Fortune*, October, 1946, page 108.

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

For Service in Chemistry

FORMAL presentation of the Priestley Medal, highest honor in American chemistry, will be made in September to Professor Warren K. Lewis, '05. Selection of Professor Lewis as the recipient of this high honor was made at the 111th national meeting of the American Chemical Society at Atlantic City, on April 17. Professor Lewis, a leader in the application of chemical engineering principles to the production and refining of petroleum, was cited for "distinguished services to chemistry." He has made important contributions to research in other fields beside that of petroleum, and has been an outstanding teacher since 1905 when he joined the faculty of the Institute. In 1936 Professor Lewis was awarded the Perkin Medal of the Society of Chemical Industry in recognition of valuable work in applied chemistry.

Class Reunions

Following are the latest reunion plans as announced by class secretaries:

1877 June 14, luncheon at the Hotel Statler, Boston.
1882 No reunion planned.
1887 June 13–15, Hotel Beaconsfield, Brookline. Friday evening through Sunday. Class dinner, Sunday, at 2:00 P.M. Chairmen, Richard E. Schmidt and N. P. Ames Carter.
1888 April 22, dinner was held at the Algonquin Club, Boston. Ralph Sweetland, host.
1892 June 12 (probable date), dinner meeting in vicinity of Greater Boston.
1897 June 10–13, Tuesday afternoon through Friday morning, East Bay Lodge, Osterville, Mass.
1902 June 12–13, East Bay Lodge, Osterville, Mass., adjourning on the 14th for Alumni Day in Cambridge.
1905 June 13–15, East Bay Lodge, Osterville, Mass.
1907 June 20–22, Oyster Harbors Club, Osterville, Mass.
1912 June 6–8, East Bay Lodge, Osterville, Mass. Ernest W. Davis, chairman.
1917 June 6–8, Wentworth-by-the-Sea, Portsmouth, N. H. Chairman, W. I. McNeill assisted by H. E. Strout.
1922 June 13–15, Hotel Rockmere, Marblehead, Mass.
1927 June 21–22, East Bay Lodge, Osterville, Mass. Ezra F. Stevens, general chairman.
1932 June 7–8, Wentworth-by-the-Sea, Portsmouth, N. H. Thomas E. Sears, Jr., chairman.
1937 June 12–14, Thursday afternoon through Saturday morning, Mayflower Hotel, Manomet Point, outside of Plymouth. Wives may attend.
1942 June 13, Campus Room, Graduate House, M.I.T. Dinner about 7:30 P.M. Bradford Darling, chairman.

Additional information will be available from your class secretary.

To the Academy

TWO staff members and two Technology Alumni in industry were among 28 American scientists who have been honored by election to membership in the National Academy of Sciences at the conclusion of the Academy's annual spring meeting in Washington. The four receiving this recognition for achievement in science are: Arthur C. Cope, Professor in charge of the Department of Chemistry; Charles H. Herty, Jr., '21, research engineer and Assistant to the Vice-president, Bethlehem Steel Company; C. Richard Soderberg, '20, Professor of Mechanical Engineering; and Robert E. Wilson, '16, Chairman of the Board, Standard Oil Company of Indiana.

Enlarged Food Laboratories

NEW laboratories, which have been equipped for the teaching and research activities of the Department of Food Technology, were opened for inspection by the Institute staff and invited guests on April 15. Named the Samuel Cate Prescott Laboratories, in honor of Professor Samuel C. Prescott, '94, who was for many years head of the Department of Biology and Dean of Science, the new laboratories occupy a considerable part of one wing of a large building on Vassar Street, Cambridge, built during World War II and formerly occupied by the Radiation Laboratory. Dr. Prescott, who retired in 1942, was present at the open house inspection.

During the war many important research projects in relation to food supply problems were carried out for the Army by the Department of Food Technology. The new laboratories greatly increase the potentialities of the Department for conducting research in its general study of methods of food production, preservation and packaging, and for adapting its work to peacetime requirements. The value of the Institute's program in food technology is indicated by the funds for fellowships which have been contributed for a period of several years by six of the country's large food concerns.

In addition to the general office for heads of the various divisions, the laboratory comprises three teaching laboratories for junior, senior, and graduate instruction; a large and well-equipped laboratory for pilot plant experimentation; a laboratory of food chemistry; and excellent laboratories for bacteriology and microbiology. A series of laboratories for research in nutritional problems, a fat metabolism laboratory, a flavor research laboratory, a packaging research laboratory, and rooms for controlled storage experiments are also a part of the facilities now open to students. Several consultation rooms, a seminar room, and a small working library and reading room aid in making the laboratory a convenient and efficient place for the training of men for the food industry, as well as for carrying out studies on a wide range of food problems.

The new facilities have been planned and brought to completion under the direction of Professors William L.

Campbell, '15, and Bernard E. Proctor, '23, and their associates who have managed to provide superior facilities economically.

It is expected that the Department of Food Technology will be housed in its present quarters until the fruition of a long considered plan for a separate permanent building, which, it is hoped, will become a reality within a very few years.

Mathematics Head

WILLIAM T. MARTIN has been appointed head of the Department of Mathematics at the Institute," President Karl T. Compton recently announced. Dr. Martin will succeed Professor Henry B. Phillips who will retire on July 1. Professor Phillips joined the teaching staff in 1907 and has been head of his Department since 1935.

Dr. Martin was graduated from the University of Arkansas with the degree of bachelor of arts in 1930. He then entered the University of Illinois which awarded him the degrees of master of arts in 1931, and doctor of philosophy in 1934. During his studies there Dr. Martin also served as a part-time instructor from 1932–1933. He carried on postdoctoral studies as a National Research Council Fellow in mathematics at Princeton University and the Institute for Advanced Study from 1934–1936.

He joined the teaching staff at M.I.T. in 1936, serving as an instructor until 1938, when he was promoted to the rank of assistant professor. From 1940 to 1941 he was on leave of absence from M.I.T. as a research associate in mathematics at Princeton University, and from 1943–1946 he was professor and chairman of the department of mathematics at Syracuse University. Returning to the Institute in September, 1946, Dr. Martin was appointed professor of mathematics and executive officer of the Department.

He is the author of numerous research papers in complex variables, difference equations, and random functions. With Professor S. Bochner of Princeton University he is coauthor of a forthcoming book on "Functions of Several Complex Variables," and is associate editor of the *Duke Mathematical Journal* and the *American Mathematical Monthly*.

Relating to Alumni Day, June 14

NINETY-NINE members and guests attended the 256th meeting of the Alumni Council in the Graduate House on April 28 to transact business for Technology Alumni and to listen to instructive talks by President Karl T. Compton and Professor Carle R. Hayward, '04. As usual, the meeting was called to order at 7:00 P.M. by Harold Bugbee, '20, President of the Alumni Association.

Charles E Locke, '96, Secretary, was reported to have had many daily visitors during his stay at the Homberg Infirmary. In his unavoidable absence the report of the secretary was read by Ralph T. Jope, '28, Treasurer. Changes in class affiliation for four men were reported. Visits to local M.I.T. clubs were made by F. Alexander Magoun, '18, to New Bedford on April 4; Erwin H. Schell, '12, and Robert M. Kimball, '33, to Worcester on April 10; President Compton to San Francisco on April 3, Los Angeles on April 7, and Chicago on April 14; Thomas P. Pitré and H. E. Lobdell, '17, to Cincinnati on April 21; Jerome C. Hunsaker, '12, to Newark on April 15; Horace S. Ford to Cleveland on April 24; and Harold E. Edgerton, '27, to New York on April 22. Nominees for posts on various committees were proposed and elected by the Council.

Parke D. Appel, '22, chairman of the 1947 Alumni Day, informed the Council on plans to date for the annual Alumni Day which is scheduled to be held on Saturday, June 14, 1947. He stated that the symposium topic would be "Aviation: Today and Tomorrow" and that the symposium speakers would be: General George C. Kenney, '11, Strategic Air Force Command; Arthur E. Raymond, '21, Vice-president, Douglas Aircraft Company, Inc.; and John C. Leslie, '28, Vice-president, Pan American World Airways; The presiding officer will be Jerome C. Hunsaker, chairman of the National Advisory Committee for Aeronautics, and head of the Departments of Mechanical and Aeronautical Engineering at M.I.T. Present plans include the customary noonday luncheon in Du Pont Court, and a banquet at the Statler Hotel in Boston in the evening, with a stein of new design available for Alumni. This year plans are made for the wives of Alumni to have a banquet of their own in the Salle Moderne at the Hotel Statler, and then to attend an evening Boston Pops concert.

President Compton, who recently returned from a trip to Hawaii and visits to M.I.T. clubs in Hawaii, San Francisco, Los Angeles, and Chicago, told of interesting experiences in participating in the activities celebrating the 40th anniversary of the founding of the University of

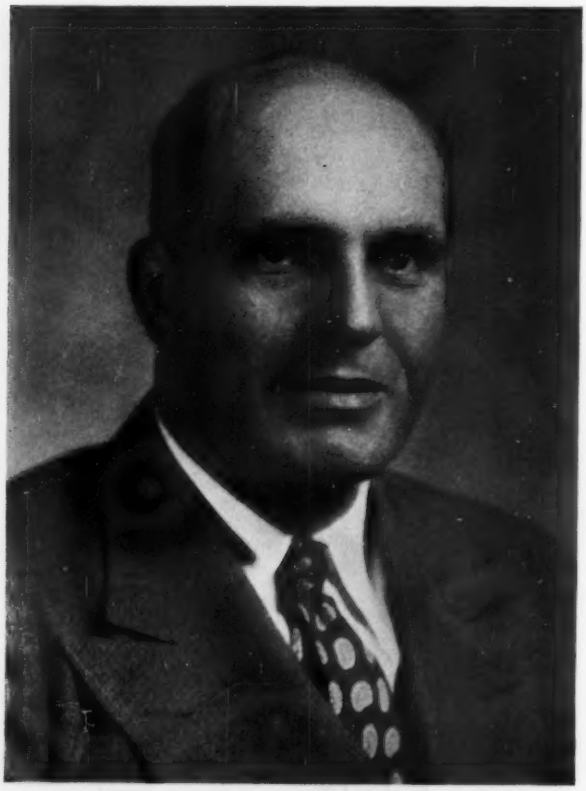
William T. Martin

. . . becomes head of the Department of Mathematics at the end of the academic year when Professor Henry B. Phillips retires.

Hawaii. During World War II this University took a leading part in war research and its present program calls for continued leadership in carrying on cultural and scientific study about the Pacific Islands and the countries in the Far East. President Compton also spoke of the activity of the Technology clubs he had recently visited, mentioning especially the club in Hawaii which is taking an active part in sponsoring civic activities.

At the conclusion of President Compton's stimulating remarks, President Bugbee introduced Professor Carle R. Hayward, '04, honorary lecturer in Metallurgy, whose topic was "What Metals Will Your Grandchildren Use?" The Council was reminded that the total tonnage of all nonferrous metals used in the world amounted to less than seven per cent of steel production. The development of the steel industry was traced from its early beginnings around Saugus and Braintree, Mass. and Cornwall, Pa., to its present gigantic operations of mining in Michigan and the Mesabi region in Minnesota. In spite of depletion of some of the larger and richer iron ore deposits, the demand for increasing amounts of steel has been offset by improvements in the technology of mining operations and in developing stronger steels which permit reduction in the size of members for a given load. The important work of the late Professor Robert H. Richards, '68, in developing techniques of handling and extracting metals in the Minerals Dressing Department was recalled.

United States production of copper, which accounted for half the world production in 1929 now accounts for only one-third of the world's supply. Large deposits of copper exist in Canada, Chile, and South Africa, but with the depletion of high-grade ores in this country, the process developed at M.I.T., making it possible to mine the huge porphyry deposits in Utah and Arizona when the copper content of ore was less than one per cent, is assuming increasing importance.



Ivan J. Geiger

. . . leaves the United States Coast Guard Academy to take up new duties at M.I.T. in June as the Institute's first director of athletics.

Director of Athletics

APPOINTMENT of Ivan J. Geiger as Director of Athletics at M.I.T. emphasizes the Institute's interest in promoting healthy recreation as well as academic attainment. Mr. Geiger comes to M.I.T. from the United States Coast Guard Academy at New London, where he has served as executive officer of physical education and intramural athletics.

As the Institute's first director of athletics, Mr. Geiger will direct a growing program of athletics and recreation for a student body of more than 5,000.

With the rapid postwar increase in enrollment, which raised the Institute's registration more than 70 per cent above normal peacetime registration, it became apparent that student interest in varsity and intramural sports, as well as various supplementary forms of recreation, would require full-time supervision of these activities. As a result, Ralph T. Jope, '28, Secretary of the Advisory Council on Athletics, recommended the appointment of an athletic director who could give all his attention to the athletic program, to which Mr. Jope since 1935 has given part of his time in an advisory capacity, in addition to his duties as treasurer of the Alumni Association and business manager of The Review.

Mr. Geiger majored in biological sciences and in 1932 was graduated from Bluffton College with the degree of bachelor of arts. He then entered Ohio State University for additional training in health and physical education, which led to the award of the degree of bachelor of science in physical education in September, 1933. Since that time he has continued studies in the Ohio State University Graduate School and will complete his thesis requirements for the master of arts degree this summer.

He began his career in coaching and physical education in the schools of Vanburen, Ohio, where he served as coach of football and basketball, and instructor in health and physical education from 1933 to 1937. From 1937 to 1942 he served as director of athletics and physical education in Vanburen schools.

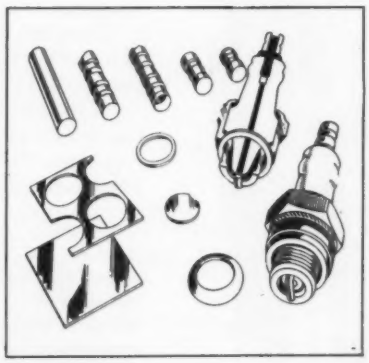
Mr. Geiger entered the Coast Guard service with the rank of lieutenant junior grade in June, 1942, as a specialist in athletics and physical education. His first assignment was as assistant to Commander Jack Dempsey in the physical training department at the Manhattan Beach Training Station in Brooklyn. He transferred to the Coast Guard Academy in August, 1942, to assist in the physical conditioning program for reserve cadets in the Reserve Officers Training School. He was assigned to the athletic and physical education staff of the regular Coast Guard Academy as head wrestling coach, track coach, and instructor of physical education in 1943. Two years later he was appointed executive officer of physical education and intramural athletics. Mr. Geiger retired from the Coast Guard with the rank of lieutenant commander in July, 1946, and remained on the staff of the Academy with the same duties under civil service status. He will come to his new post at M.I.T. early in June.

BUSINESS IN MOTION

To our Colleagues in American Business . . .

The automobile industry is regarded by suppliers as a highly desirable customer. Its orders are large, and strict insistence on quality standards keeps a company on its toes. The industry's demands for ever better materials, higher production, and lowest possible prices consistent with quality have been in part responsible for making the automobile business America's greatest, giving employment to one-seventh of our country's workers.

It sometimes surprises industrialists who do not have direct contact with this great industry when they learn how painstaking is the attention given the smallest item. Take parts for spark plugs, for example. Revere supplies free-cutting brass rod for the terminals. This metal makes swift manufacture by the millions possible in automatic machines. Free-cutting brass is selected from the many available types of brass, because it is best for this fabrication process.



A spark plug also has gaskets, three of them. The obvious material for a gasket that is subjected to heat is copper. But what copper? There are many coppers. Silver-bearing copper is chosen, because it resists annealing, or softening, at spark plug temperatures. This copper is not the cheapest, but the best for its job of maintaining the seal required to prevent blow-by and loss of power.

Take an automobile down, part by part, and you find from 37 to 73 pounds of copper and copper alloys, each type chosen with the greatest care, no matter how small the individual part. Just as nothing seems to be too big for the automobile industry to accomplish, so nothing is too small for it to study. To be a supplier to that industry is indeed both an honor and a responsibility.

It does not seem that the future will produce a rival for the automobile industry in size, but more and more industries are rivaling it in their meticulous search for ways to make better goods, faster, and at lower prices. In that endeavor Revere collaborates closely with many of its customers. Any other supplier who is asked, is only too glad to place his accumulated knowledge at the disposal of buyers.

No company can stand alone; it must obtain the cooperation of many others, and utilize available experience in such diverse fields as design, material selection, fabrication, public relations, merchandising and advertising.

In every industry there are capable sources of such help, and today more than ever it is essential to go to them.

I like to think that American industry is a collaborative as well as competitive whole, in which employers and employees, sellers and buyers work together, each factor contributing in its own way, and each profiting accordingly, as in the automobile industry.

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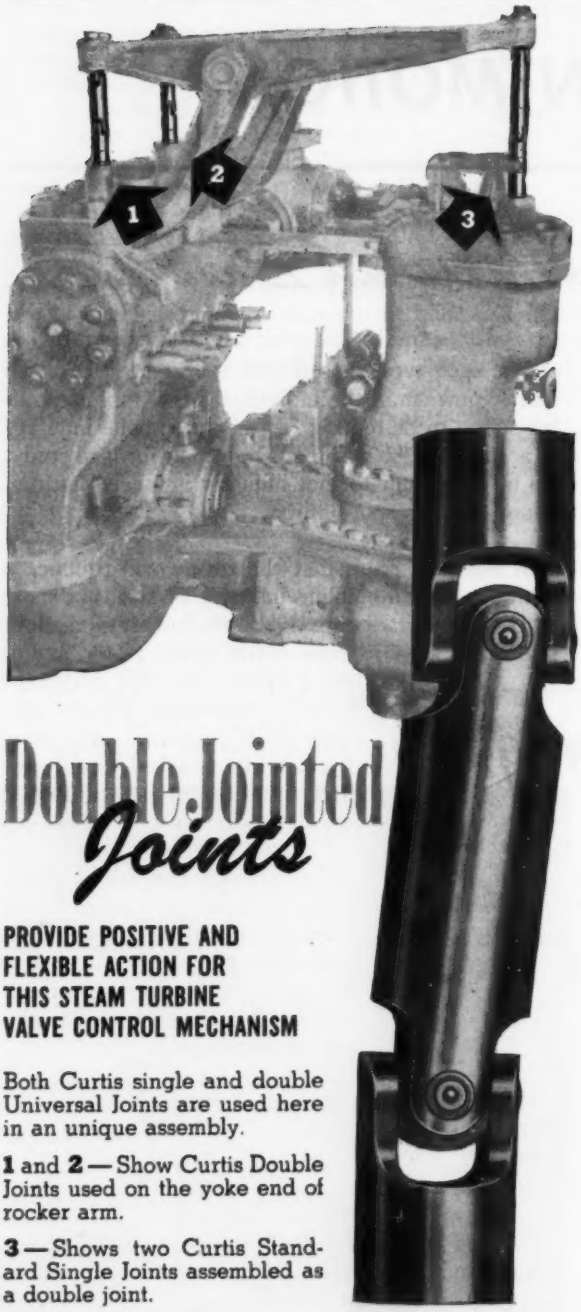

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THE TREND OF AFFAIRS

(*Concluded from page 458*)

system of color television has been developed experimentally, although commercialization of this system is reputed to be several years in the future. In addition, wartime research in the electronics field has produced many improved techniques which will be directly applicable in further improving television images.

All this would seem to indicate that technical limitations are hardly the bottleneck in making television currently available in the United States. Yet, except for licenses granted to a few dozen television stations (most of which are in the process of construction rather than engaging in maintaining reliable service) and except for the operation of television receivers in so few American homes as to be statistically insignificant, television service in the United States is still nonexistent.

Unlike most engineering developments, television has suffered from an affliction which, with the increasing publicity that applied science has received in recent years, may cast its blight on other technological advances as well. This has to do with the avidity with which new products of science are sought by large portions of the population. The war has finished the job (if it needed finishing) of converting the skeptics.

Television affords an excellent example of the complete reversal of earlier skepticism. The reversal is now so complete that the public is ripe and conditioned to desire the products of science and engineering decades before the technical and economic stability can be brought to homology. It may be said — and in fact has been said in Dr. Horton's earlier Review article — that:

> Television has a peculiar significance in the progress of the machine age, not because of any grandeur of its technical achievement or because of its contribution to human well being, but because it marks the final defeat of the skeptic. It seems probable that this most recent accomplishment of electrical communication has rung down the curtain on that scornful chorus which has chanted the refrain, "It can't be done," at the approach of each new application of science since the steam engine, if not since the wheel and the lever. For perhaps the first time in history the public has foreseen an invention in advance of its realization, and, encouraged by the results, has replaced its old pessimism by a too abundant optimism. The technically sophisticated, however, will do well to temper their scorn; they are merely reaping their own whirlwind.

The matter of importance to engineers and scientists is that the public, having anticipated an invention in advance of its realization, is likely to be oversold on technology. It matters not that public misconception may have been entirely unintended or that it might have arisen because those in technological pursuits failed to make clear the true significance of their demonstrations. If, within a reasonable time, realization does not follow disclosure of successful experiments it may be expecting too much of a public to evaluate the reasons for delay. It is not improbable that interest in television has already waned before its services have really begun. After two decades of suspense in this fast moving world, and one decade of technically acceptable images, will the average man produce a verdant blush of enthusiasm when television service finally does round that famous corner?

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MAINTAINING STUDENT HEALTH AT M.I.T.

(*Continued from page 462*)

is present at all regularly scheduled athletic events. This physician, either directly or through the trainer, has the entire responsibility for determining whether a student is able to play or not and of course takes no chance of injuring a student's health. All injuries treated in the clinic which have been incurred in athletic activity are reported at weekly intervals to the Athletic Association, giving the coaches and others interested data which may be of use in determining the basic physical condition of the men out for various squads.

Plans are now being made for reorganization of the Institute's athletic and recreational facilities, and it is anticipated that under the new program, which is expected to play an important role in the general health of our students, the Medical Department will serve the athletic director in an advisory capacity whenever its services are desired.

Preventive Medicine

An important part of the Department's activities is the prevention of disease in every possible manner. One of the requirements for admission is that the prospective student be immunized against typhoid and smallpox. These and other immunization procedures are constantly being done by our staff. Institute personnel planning travel to other sections of the country or to foreign countries consult the Department for information concerning health conditions there.

Because of predictions of public health authorities of an influenza epidemic during 1946–1947, inoculations of influenza vaccine, Types A and B, were offered to all members of the Institute. About 1,200 accepted the offer and were immunized. The expected epidemic did not materialize except for a mild outbreak in March during which 43 cases of respiratory infection, more severe than ordinary colds, were hospitalized in the Infirmary. Of this number, only two had received influenza vaccine. This number is too small to be of statistical significance, however.

In co-operation with the Massachusetts State Department of Health a program of making x-rays of the chests of as many members of the Institute as possible was carried out in April and May. The early response was not as encouraging as the Department had hoped, but enough information was obtained to warrant the recommendation that annual x-rays of Institute personnel be required. Tuberculosis still remains the chief cause of death in the college age group, and the Institute hopes to be among the leaders in the educational field in eliminating this disease.

The Medical Director is a member of the Safety Council of the Institute, which has as its main function the elimination of any situations or circumstances which threaten the health and safety of Institute personnel.

Although the Department does not have the facilities to care for the members of the families of students, faculty,

(*Continued on page 480*)

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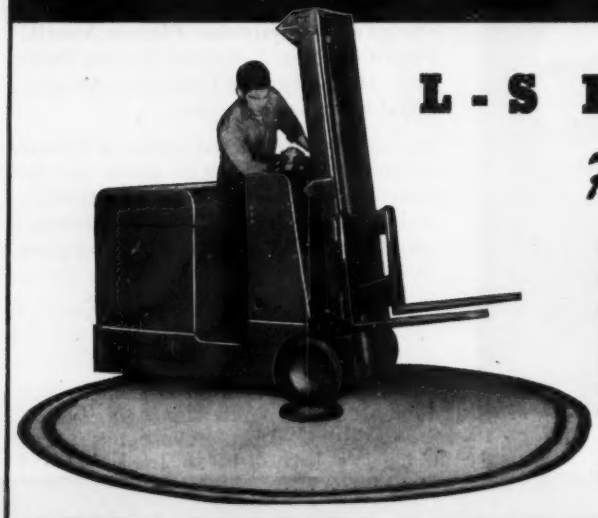

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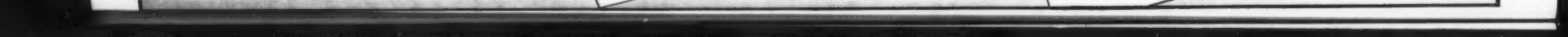

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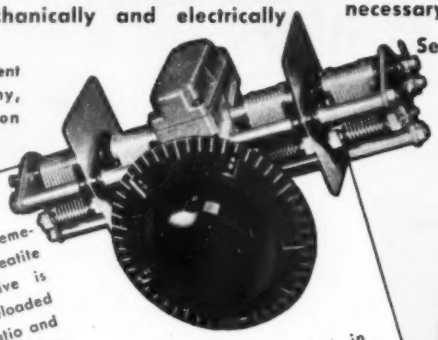
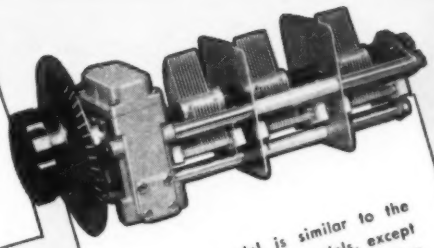
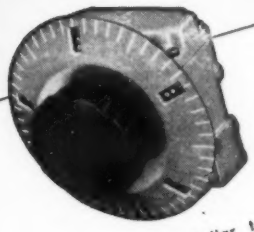


This PW Condenser is of extremely rigid construction with Steatite stator insulation. The drive is through an enclosed preloaded worm gear with 20 to 1 ratio and the rotor shaft is parallel to the panel. Plate shape is straight-line frequency when the frequency range is 2:1.

PW Condensers are available in 2, 3, or 4 sections in either 160 or 225 mmf per section. A single-section PW Condenser with grounded rotor is supplied in capacities of 150, 200, 350 and 500 mmf, single spaced, and capacities up to 125 mmf, double spaced.

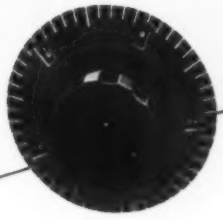


The NPW model is similar to the other PW Condenser models, except that the rotor shaft is perpendicular to the panel. Three sections . . . each 225 mmf.



NPW-O uses parts similar to the NPW Condenser. Drive shaft perpendicular to panel. One TX-9 coupling supplied.

The PW-O uses parts similar to the PW Condenser. Drive shaft parallel to panel. Two TX-9 couplings supplied.



The PW-D micrometer dial can be read direct to one part in 500. It revolves ten times in covering the complete range and fits a $\frac{5}{16}$" diameter shaft.

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MAINTAINING STUDENT HEALTH AT M.I.T.

(*Continued from page 478*)

or employees, it does stand ready to act in an advisory capacity in such matters as choosing a physician, gaining admission to hospitals, and in furnishing directory service for those who need to consult specialists in other sections of the country.

The Medical Department is financed from general Institute funds. In order to supplement the amount of money available and to increase the services rendered by the department, a charge is made for some special services. Residence in the Infirmary costs the student from $2.00 to $3.00 per day, and x-rays, unusual laboratory procedures, electrocardiograms, eye refractions, and consultations by the dermatologist and otolaryngologist are at the expense of the student though at much lower rates than are paid by the community. Whenever a student is transferred to another hospital for major surgery or for the care of communicable diseases, he is responsible for all expenses incurred; likewise, if a consultant is needed, his fee must be borne by the student or his family. In no instance, however, is a service denied to a student because of lack of funds. A needy student fund is also available from which a student may borrow money for unusual medical expenses.

Visiting Committee

The Visiting Committee on the Medical Department met at the Institute on November 6, 1946*, at which time the previous year's work was reviewed and pressing needs of the Department were discussed. It was brought out at the meeting that returning veterans were adjusting very well to the resumption of their academic studies and were in need of psychiatric attention only to the same extent, in general, as civilian students. In the opinion of the Medical Director, however, a marked increase in the amount of psychiatric time available to students was needed, and the committee voted to recommend the employment of a full-time psychiatrist as soon as a suitable person should become available.

The committee also voted to recommend the employment of a part-time physiotherapist. Because several of the activities of the Department are seriously handicapped due to lack of space, it also voted to recommend that nearby space in the Institute be made available to the Medical Department in order that its facilities may be used in a more effective manner.

Up to the present time the Committee's recommendations for added space have not been carried out because of the present demands of many departments occasioned by

(*Concluded on page 482*)

* Members of this Committee for 1946–1947 are: W. Cameron Forbes, chairman, Samuel C. Prescott, '94, Dr. W. Jason Mixter, '02, Dr. James H. Means, '06, Ellis W. Brewster, '13, Dr. Egon E. Kattwinkel, '23, Dr. T. Stewart Hamilton, and Laurence F. Whittemore. Committee members present at this meeting included: Messrs. Forbes, Prescott, Mixter, Means, Kattwinkel, Hamilton, and Whittemore. Mr. Brewster was absent. Also present were: Dr. Dana L. Farnsworth, Medical Director; Dr. George W. Morse, Medical Director, Emeritus; Dr. John W. Chamberlain, '28, Assistant Medical Director; Karl T. Compton, President of M.I.T.; Horace S. Ford, Treasurer of M.I.T.; and Mr. Forbes's secretary, Lytton H. Dowson, who acted as secretary of the meeting. The group was joined at luncheon in the Silver Room of Walker Memorial by Dr. Walter O. Blanchard, Assistant to the Medical Director.

"This is a story of the heating at Notre Dame University. A similar story might be told of the excellent management of the heating installation in the Institute's great buildings. It's been a Webster Vacuum System from the beginning."

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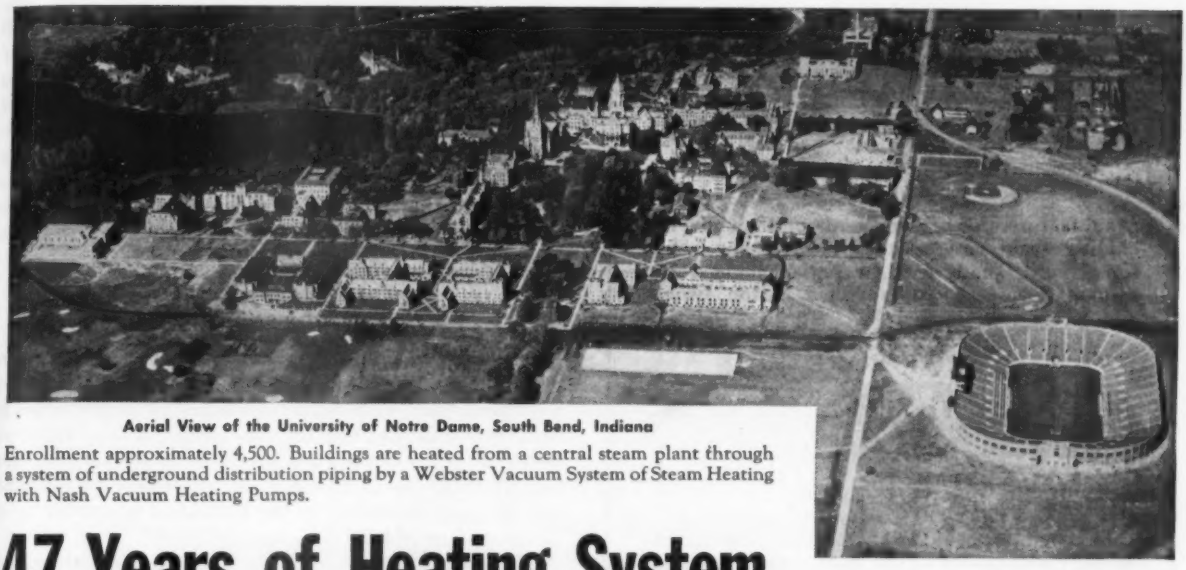

Aerial View of the University of Notre Dame, South Bend, Indiana

Enrollment approximately 4,500. Buildings are heated from a central steam plant through a system of underground distribution piping by a Webster Vacuum System of Steam Heating with Nash Vacuum Heating Pumps.

47 Years of Heating System Management at Notre Dame

A great university is, among other things, big business, receiving and disbursing large sums, maintaining and operating a large physical and mechanical plant. Consistent, competent management of the physical plant, such as is revealed by the record of heating system management at Notre Dame, is essential to success.

The first proposal for a Webster Vacuum System of Steam Heating at the University of Notre Dame was dated June 27, 1899—the installation, containing 16,913 square feet of radiation, was completed in 1900.

Thus started a cooperative business relationship that has continued for forty-seven years. During this period inevitably changes have occurred in architects, engineers, contractors, University plant personnel and Webster service personnel. But the service of this *business* institution to the University has been continuous. As new requirements arose, as additions and changes were made, as worthwhile new developments in the heating art became available, changes have been made in the University's heating installation to keep it up to date.

This great heating system now totals 320,000 square feet of radiation—twenty times the size of the original Webster Vacuum System. And each increase has been accompanied by appreciation of the increased importance of quality standards both in material and in operating and maintenance procedures.

Currently, to assure at the same time comfort with maximum economy of fuel and minimum operating and maintenance costs a Webster Moderator Control System is being installed, designed to (a) balance distribution so that all radiators may be partially heated in mild weather, (b) apply automatic control-by-the-weather to the entire installation, (c) centralize all manual control to 38 zones at a single operating station.

How well these results are accomplished must necessarily be the subject of a later report. In the meantime, our experience is available to *help you in your heating system management* problems.

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MAINTAINING STUDENT HEALTH AT M.I.T.

(*Concluded from page 480*)

the large increase in enrollment. Until more room is available, the Department cannot expand its facilities. When five or six additional rooms are secured, the staff should be able to give maximum service under nearly ideal conditions for many years. There would have to be very unusual conditions indeed to call for any further major increase in space requirements for the Department.

The possibility of establishing a permanent chest x-ray program was discussed, and it was unanimously voted to recommend that it shall be made obligatory for all students, both full and part-time, to have chest x-rays taken annually.

Health Education Center

In many colleges formal courses in hygiene are given to freshmen. At the present time the Department is not convinced that the good accomplished in such courses is sufficient to compensate for the amount of time required in an already overcrowded schedule. A health program can probably be furthered most effectively by prompt and thorough attention to the individual whenever he is threatened or in trouble.

The aim of the Medical Department is to diagnose and treat the illnesses that occur in the Institute family, to prevent disease in any manner possible, to act in a medical advisory capacity in a wide range of health and personal problems, and to be an educational center for the Institute so far as health matters are concerned. To carry out these aims a staff has been assembled which co-operates in much the same manner as would a group clinic under private auspices. The staff endeavors to carry out its work in a personal, quiet, and dignified manner with the highest of professional standards in mind. By so doing the Department hopes to earn its right to vigorous support and co-operation from all members of the Institute.

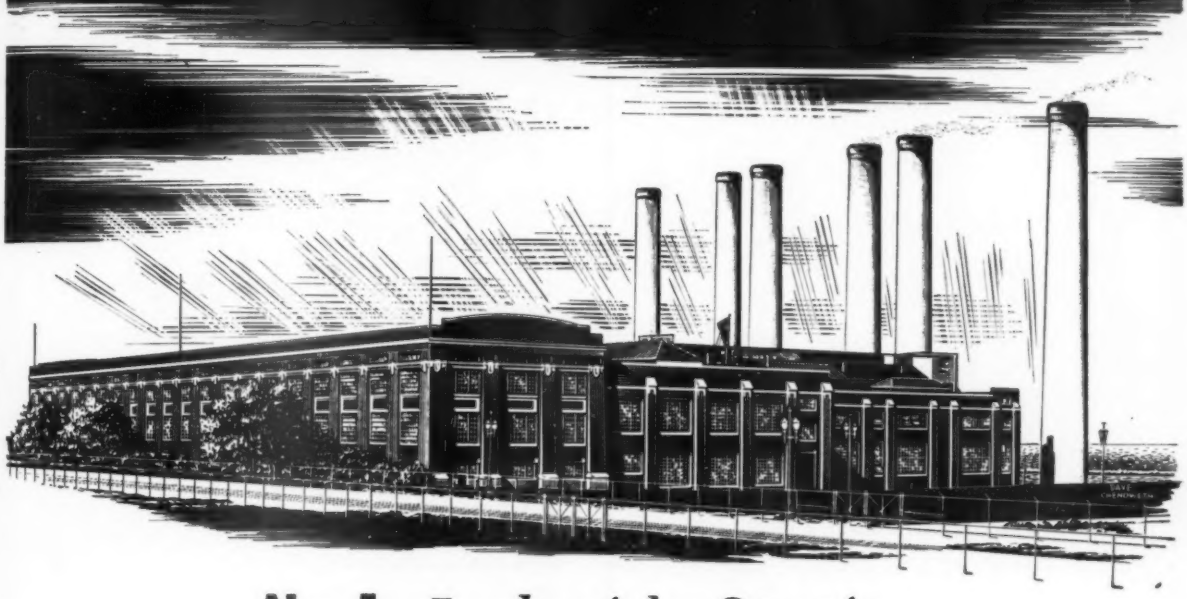
THE SCIENTIFIC WAY

(*Continued from page 464*)

Even so, a mere moment's glance into the history of science is enough to disabuse us of the notion that practical application is the prime motive of research, or that a research is begun only when a clear objective has been defined in terms of a specific theory, technique, or application to be achieved. In general, the knowledge out of which some practical advantage or benefit grows has itself been long in existence before the application is made — and this is true in general, even in our own time of skill in applied research for a definite purpose. Often, moreover, new knowledge comes to light at a time and in a way having no relation whatever to possible applications. Practical usefulness is good, of course. For demonstration of that, all we have to do is look at the long curve of history where the trend, in spite of many aberrations and fluctuations such as those that indicate the troubled spots and unsettled problems of today, has been steadily toward an easier and richer life for the ordinary human being. In

(*Continued on page 484*)

History-making power stations



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In 1920 the new Lakeside Station, of what was then known as The Milwaukee Electric Railway & Light Co., was a bold experiment that has much to do with your life today. For every man, woman or child who reaps the benefits of American industry has a stake in steam. And Lakeside started something important. It was the first central station designed to operate exclusively with pulverized fuel. Today you will find that pulverized coal, ground flour-fine, is the generally accepted way of firing the largest power station boilers, and is also widely used for boilers in the middle-sized range. However, in 1920 the situation was very different. Most power engineers were frankly skeptical of Lakeside's success.

But Lakeside more than vindicated its designers. Not only did it prove the practicability of pulverized fuel; it demonstrated its economy in the most convincing way possible, by establishing the lowest BTU rate (the measure of power station efficiency) of any station in the country. Combustion Engineering supplied the pulverized fuel grinding and burning equipment for the initial installation at Lakeside and, for the later extensions to the station, the steam generating equipment as well.

Today we take a lot for granted. Miracles no longer seem miraculous. But someone has to apply new knowledge for the first time before a marvel can become a commonplace. Lakeside engineers did this — superbly. We, of course, are gratified that so frequently the high points of power progress are linked with C-E, that our steam generating units and allied equipment are found in so many of the nation's "firsts". We invite you to let C-E's forward looking policy work for and with you on your requirements.

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These three factors are the unwritten plus-values in every C-E contract —

Knowledge — *to solve today's, and tomorrow's, steam generating problems.*

Experience — *to interpret, from a world-wide background in every important industry, the specific needs of each installation.*

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THE SCIENTIFIC WAY

(*Continued from page 482*)

the minds of the generality, practical usefulness, then, is naturally enough the greatest justification for science. To scientists themselves, it is satisfying to see that the general welfare is aided by practical applications of the knowledge which they accumulate. They would be considerably less than human otherwise. But I believe their greater satisfaction comes from other sources. It comes primarily from being able and enabled to fulfill the demand, or requirement, or faith, which is the essential condition for being a scientist.

Essentials for Being a Scientist

What is this condition? It is not a mastery of mathematics or physics or chemistry, nor an adeptness at devising experiments, nor a more than ordinary power of logical analysis. It is not even a heightened capacity for the rare combining of intelligence, imagination, and intuition in the act of creative thought which constructs the great hypotheses and syntheses. The essential condition is not the possession or the exercise of any of these attributes, though each is a great value in itself. Rather, the essential condition is an intense, innate conviction that knowledge is good, that knowing is good, and that therefore to increase knowledge by conscious willed exertion of the intelligence is both duty and high privilege. We recognize that knowing is hazardous but we declare it worth the risk. To follow the scientific way is thus a profession of the faith that, as we know the truth, the truth will make us free. Here our distinction of motives or incentives becomes clearly set out. As knowledge contributes to the general welfare, whether through applied science, engineering, or some other avenue, it is a good in immediate or pragmatic senses. In the sense of the essential condition, however, of the scientific way, knowledge is good in and of itself, without regard to such immediate or pragmatic benefit as it may offer.

Now if we regard knowledge thus highly as a good, absolute in itself, we comprehend that knowledge has an integral quality. We comprehend that it has a virtue, that it has an inherent right to our respect for its integrity. The man to whom this recognition has come is therefore humble before knowledge. He will not trespass upon it, but he will rather accede to knowledge, seek to understand it, and to participate in it. Therefore he strives for objective, selfless honesty in approach, in definition, in operation. Here in this objectivity of attitude, far more than any set of working procedures, is the reason for the essential unity of the various scientific disciplines, whether in nuclear physics or in classical philology.

We come each to our own comprehension of the individual human intelligence confronted by the vast mass of knowledge. The contrast is great, so great that the attainment of a thorough grasp in a lifetime seems impossible on the face of it. Yet we know that a working relationship is attained, and we must recognize this as one of the two or three most amazing and humbling facts. We come each to that comprehension only slowly at best, with many false starts and departures from the true course. History in general, and the history of one's own discipline in particular, are of profound worth in this search, in great

(*Concluded on page 486*)

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THE SCIENTIFIC WAY

(*Concluded from page 484*)

measure because through reciting the courses which others followed history may safeguard us against pitfalls which they discovered. The aim toward which the student of science perseveres is that of ultimately doing original investigation, exploring the unknown. Just as in preparing for this he repeats classical experiments in his studies, so in working toward his philosphy of science, that is, his comprehension of the relationship between himself and knowledge, he is wise to review classical experiences.

Students of science see their own projects state unequivocally one of the great and hard lessons which all travelers along that way must learn — the lesson that in research, in the exploration of the unknown, the price of one success is often many failures. Therefore, the effort and ability to detect failure and error early, and the capacity and strength to abandon a line of approach however treasured and however far committed, once its fruitlessness is sensed, are vital elements in the complex compound of plan, reason, patience, and courage out of which new knowledge is precipitated. The great quality is not simply to be able to stand up under disappointments, but to be able to do so without losing the zest and exhilaration that should attend success. The fascination and the compulsion of the characteristic quality of science are that a discovery made or a question answered, reveals new unknowns to seek and new questions to ponder.

Before us is the great and heartening awareness of another truth which is closely akin to this last, and which lies at the vitalizing center of man's existence as a sentient being. Science is a regenerative system. So is the combined act of will and intellect which the scientific way calls forth. By effort of the will, the intellect is exercised. That exercise, in turn, renews the effort of the will, and so the cycle is repeated again, opening one of the deepest satisfactions man can know. To some who elect to follow the scientific way, success, in the world's terms, will be attainable, and there will be satisfaction in it. To all, there will come as there must, reverses, setbacks, disappointments — in the world's terms. These are temporal and do not matter. What does matter is the achievement of that serenity, equanimity, and balance which come from certainty concerning what men do and who they are as creators — and creations — of this conjoint, self-replenishing, and inexhaustible power that resides in will and intellect.

MAN AS A GEOLOGICAL FORCE

(*Continued from page 471*)

est scourges that ever hit the European woodlands was the blast furnace, invented in the Fifteenth Century. Because these were run originally on charcoal, the drain on timber reserves became so heavy that in Great Britain the parliament passed a series of acts between 1558 and 1584 designed to limit the regions in which iron works could operate. The legislators feared for the supply of shipbuilding lumber. Except when war forces the suspension of such reasonable measures, an increasing number of forests in Europe and America are being maintained on a sustaining basis. Indicative of the extent to which the pendulum has swung is the fact that British North Borneo had a conservator of forests.

Wherever the natural cover is stripped away and the climate is subarid or slopes are steep, the topsoil starts to move. There appears to be little doubt that man and his livestock have helped to enlarge desert areas and have increased the intensity and number of dust storms. Iran, Syria, Greece, Italy, and much of North Africa, not to mention a good many areas closer to home, are regions where once fertile land has become barren through the efforts of men and their animals to stay alive. On the other hand, terraces to hold the soil on steep slopes were a feature of agriculture in pre-Christian Palestine, in China, the Philippines, and throughout the ancient civilizations of Central and South America. Bennett estimates [11] that the walled terraces of the Incas represented an investment of about $18,000 per acre in terms of modern labor costs.

One interesting example of man's interference with natural processes that should be called soil creation, rather than soil conservation, is occurring in Honduras in the valley of the Ulua River.[12] Like many other rivers loaded with silt, it tends to build up its own bed above the level of the valley. As the result of reoccurring floods, large swamp areas have formed. Because the soil and climate of this valley are ideal for the growing of bananas, a full-scale engineering approach, involving heavy equipment and large expenditures, was made to reclaim these swamps. By controlling the areas that are flooded and the velocity of the flow, the river has been made to deposit its

(*Continued on page 488*)

[11] Hugh H. Bennett, *Soil Conservation*, page vi (New York: McGraw-Hill Book Company, Inc., 1939).

[12] *The Scientific Monthly*, February, 1946, page 117 ff.

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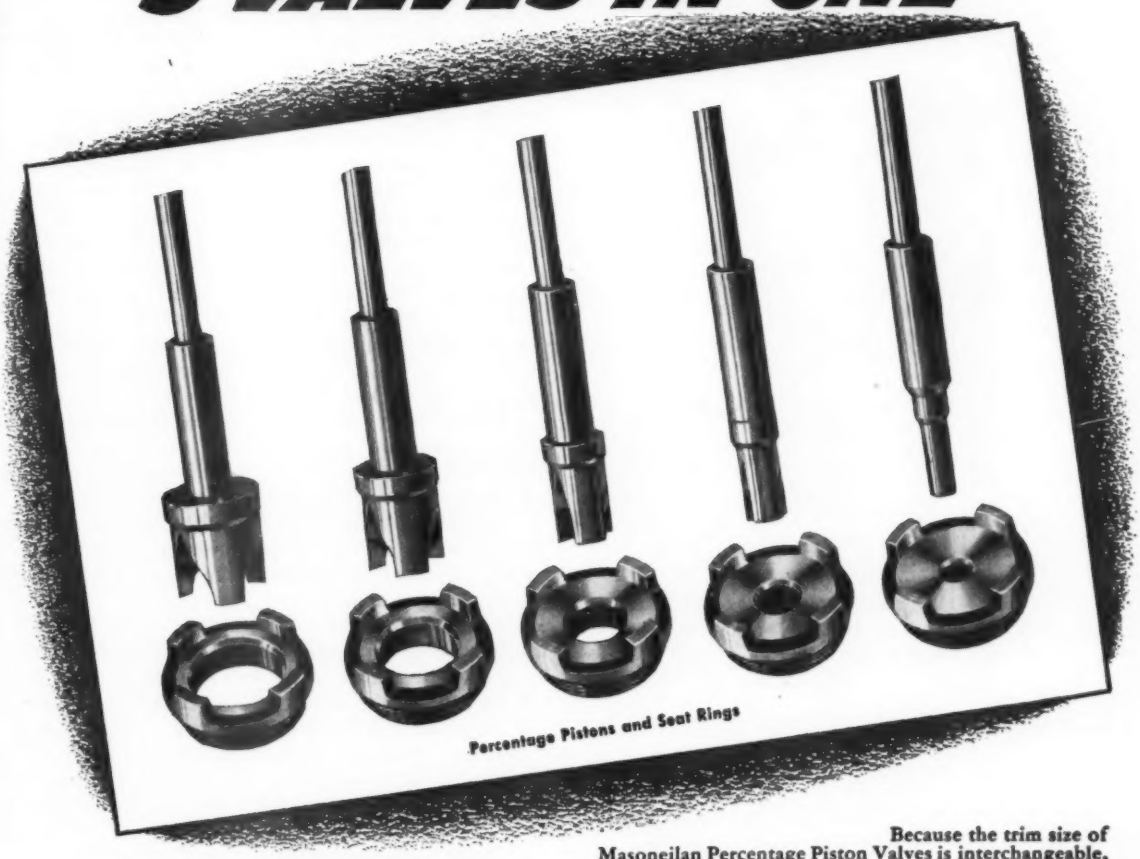

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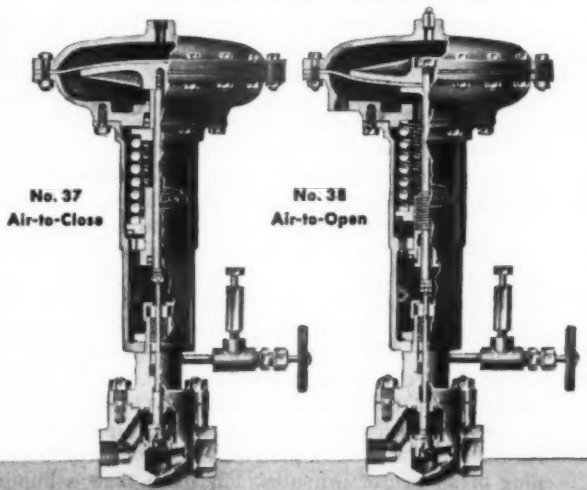

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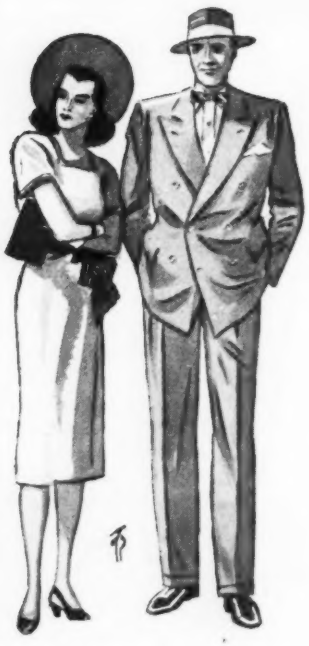

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MAN AS A GEOLOGICAL FORCE

(*Concluded from page 486*)

silt as desired. Up to World War II more than 15,000 acres had been built up by controlled sedimentation, and 100,000 acres are available for further treatment. The average rate of deposition is about three inches per year.

Tinkering with geography, at least on a minor scale, is getting to be a fairly frequent consequence of engineering. The building of the Denison Dam in Texas, for example, has created a reservoir with an area of 220 square miles, making it the fifth largest artificial waterway in the United States. The Grand Coulee Dam, largest in volume and second highest of the masonry structures of the world, has backed up a lake 151 miles long. The reservoir behind Boulder Dam is carrying out for the Colorado River almost the same function that the Great Lakes perform for the St. Lawrence. Acting as huge silt traps, the Great Lakes make the St. Lawrence such a clear stream that it cannot build a delta. The Colorado, on the other hand, has been a notorious silt bearer, and has built up its delta and its bed so rapidly that it has periodically choked off its outlet to the Gulf of California and has flooded into the Salton Sea. Below Boulder Dam the Colorado now runs clear. But silt is deposited in the reservoir at a rate which may destroy its usefulness in a few centuries unless corrective steps are taken.

That outlook illustrates a persistent feature of some of man's most impressive engineering accomplishments. Built with the utmost economy of material and depending frequently on stressed members made of materials like iron and aluminum which do not exist in nature as metals, these structures can function only if continuously maintained. Many masonry structures have already demonstrated a most respectable resistance to the ravages of time, and in the artificial rock, concrete, man has created a material comparable in durability to most natural substances. But many of our bridges would collapse if subjected to but a few decades of neglect. A few centuries of neglect, and only traces would remain of many towns, irrigation systems, and roads.

Permanence, however, is a relative term. Even the greatest of natural features are not eternal. The Appalachians, once far higher than they are today, rose out of a shallow sea. As far back as geological history can be traced, similar cycles have kept the earth's surface in a state of slow flux. Mountains have been reduced to plains. Plains have been bent and broken into mountains which have been carved into new valleys by strange rivers. Virtually every prominent feature of the North American landscape has assumed its present shape during the last 50,000,000 years, the duration of the present geological era. Man is a recent visitor to this planet. Only yesterday, even by his own time scale, has he acquired the numbers and the techniques that can produce any material effect on the earth's appearance. In spite of current fears that man is about to hoist himself right out of a civilized existence, there is at least equal precedent for the speculation that perhaps we are still at the beginning of an age of primates. For more than a hundred million years life at its highest, most involved form, was represented by the trilobites. The age of reptiles endured for almost as long a period. At his current rate of progress, if that is the word, man needs only a fraction of that time to reshape the world.

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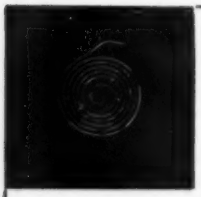

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ENGINEERING AND EDUCATION

(*Continued from page 468*)

acquaintance with some of the great masterpieces of literature and an understanding of their setting in, and influence upon, civilization. There must be developed the moral, ethical, and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude. Finally, the program has as its purpose the attainment of an interest and pleasure in educational and cultural pursuits which thus serve as an inspiration to continued study.

The list is interesting as an indication of what the modern engineer expects of the humanist and social scientist. Any group of teachers who could accomplish so much would certainly be supermen. For most of us, however, the results achieved will be less than the desired goal. The adoption of clearly defined objectives, even if somewhat more limited than the ideal, will assist in achieving the ultimate objective in engineering education.[5]

The Quest for Literacy

The first of these, and the single thread which runs through any effective program, is the quest for literacy, that is, the ability to listen, to read, to speak, and to write. It is not implied that literacy, even in this larger sense, spells ability. A man may be able, even though in many fields he may be illiterate. Possibly, even the converse is true; that a stupid person is perchance literate. When, however, one recent survey shows that 40 per cent of the persons questioned believed that the United States was an active member of the League of Nations, or when another assigns to American college graduates an effective vocabulary of 1,000 words, it is obvious that the modest objective of literacy, as defined above, is not to be despised. After all, whether in war, love, or ordinary intercourse, words are swift as arrows and strong as swords. In a democracy, they are essential to leadership, as witness Winston Churchill.

Fortunately, at every level, literacy is one of the arts which can be taught. Obviously, too, it is of practical importance to the engineer who must not only find his problem, and solve it, but also sell the solution to other men.

There is also time to introduce the engineer to history. For our purpose, the important thing is a sense of perspective which comes of studying the past, and a realization that the world was not created in the year 1900. These

(*Continued on page 492*)

[5] H. P. Hammond, *et al.*, "Report of Committee on Engineering Education after the War," *Journal of Engineering Education*, 34:589–614, (May, 1944).

"Have You Heard About CHATHAM PINES?"

"No, what about it?"

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ENGINEERING AND EDUCATION

(*Continued from page 490*)

aims may be achieved either by a survey centering around some common theme, such as the history of civilization, or, preferably, by the more intimate study of single vital periods.

Here it is especially important that the end results be kept in view. In all ages history is the basis of statesmanship, and in a democracy all men are statesmen to some extent at least. In devising the means and physical instrumentalities which determine our mode of living, the engineer plays a much greater role as statesman than other citizens. The quotation from Disraeli, "Statesmanship is the ability to discern the possible," needs to be balanced by that fine phrase of Talleyrand, "The statesman always carries the future in his heart."

In the study of history, it is by no means impossible to develop interests and a sense of proportion which are of enduring value. Thomas Fuller said long ago: "History maketh a young man to be old, without either wrinkles or grey hairs, privileging him with the experience of age, without either the infirmities or inconveniences thereof. For learning endueth men's minds with a true sense of the frailty of their person, the casualty of their fortunes and the dignity of their soul and vocation." But the study of history also has its purely utilitarian aspects as well. If George Santayana was even partly right when he said, in *The Life of Reason*,[6] "Those who cannot remember the past are condemned to repeat it," then neglect of the past is surely dangerous.

Among the social sciences a choice must be made. The engineer's professional interests make economics essential. Psychology, especially the psychology of groups, also appears to be a field which can be studied with advantage in engineering colleges.

Developing a Professional Outlook

For thousands of young engineers the last period of formal education comes in their senior year. In many engineering colleges, the fourth year is one which provides specialized electives and, in some cases, during which the student prepares a substantial thesis based on his own reading and research. It seems natural that the student, who will soon begin the practice of his profession, should also have a reasonable choice of subjects on the humanistic side of his education during his last year of formal academic training.

One program, already in effect at M.I.T., provides four senior electives: (a) International Relations; (b) History of Science and Thought; (c) The Fine Arts; and (d) Western World Literature. Many others might readily be suggested, but there are practical limits to what can be done with thoroughness and distinction. The first two have fairly close correlations with scientific and technical subjects. The fine arts lend themselves to the laboratory method where even the amateur may learn by doing, and the course in literature gives further opportunities in expression.

A program which aims to provide a certain background of the humanities and social sciences in a technical

(*Concluded on page 494*)

[6] New York: Charles Scribner's Sons, 1922.

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ENGINEERING AND EDUCATION

(*Concluded from page 492*)

course is subject to two opposite criticisms. It leaves out much, as is inevitable. More seriously, it carries no single subject to an advanced level. The student who graduates is neither a historian, nor an economist, nor a literary critic. Such criticism, although valid, fails to recognize the broad humanistic objective. By definition and necessity, the student for whom we are planning is at least a potential scientist or engineer, to whom such courses in the liberal arts and the humanities, if well given by inspiring teachers, may offer illumination and reveal unsuspected relations.

For an experiment in general education of such obvious importance, the engineering colleges have both advantages and disadvantages. The chief disadvantage is not, as is sometimes assumed, any lack of interest among faculty, alumni, or students. The popularity, in at least one engineering college, of fairly intensive courses, of such subjects as modern philosophy and the history of science, is ample proof that interest is not lacking. The lack of time is a real difficulty, and this is being overcome, to some degree, by increasing emphasis on graduate studies.

There are, however, correlative advantages. The humanist and the historian are entirely unhampered by sharp divisions between and within departments. No faculty is so little likely to be misled by premature and, as it seems to me, illusory attempts at synthesis. Above all, there is a climate which allows experiment and change without the binding hand of vested academic interests.

At least 16 of the major engineering colleges are planning in different ways, but with similar objectives, co-ordinated programs in the social sciences and humanities. The educational results are well worth watching.[7]

[7] H. P. Hammond, "Report on Humanistic Social Studies in Engineering Education: Introduction"; Robert M. Boarts and John C. Hodges, "The Characteristics of the Humanistic-Social Studies in Engineering Education: A Report," *Journal of Engineering Education*, January, 1946, pages 338-351.

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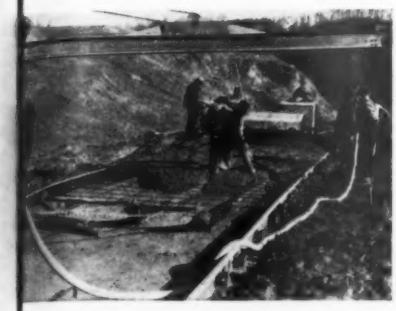

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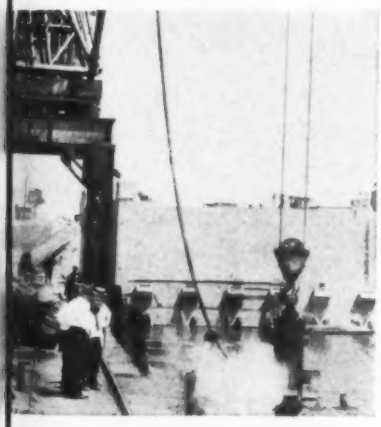

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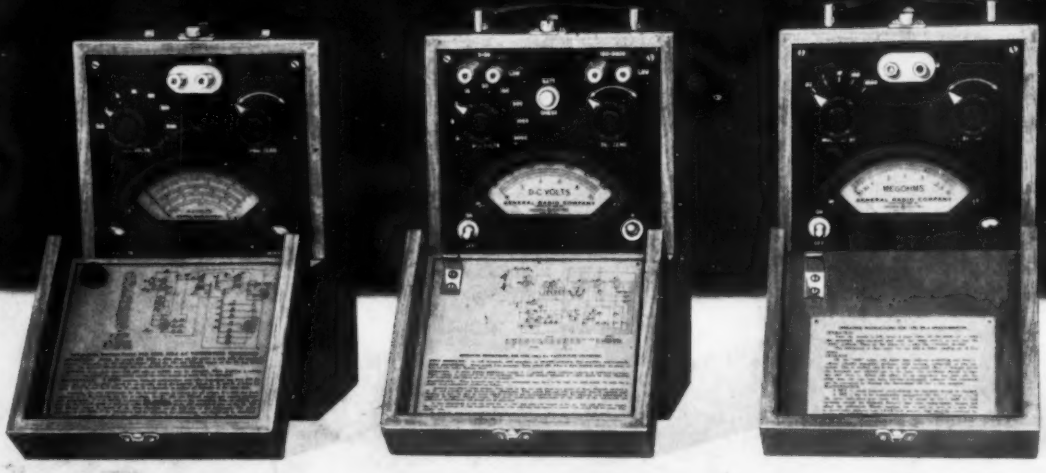

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